

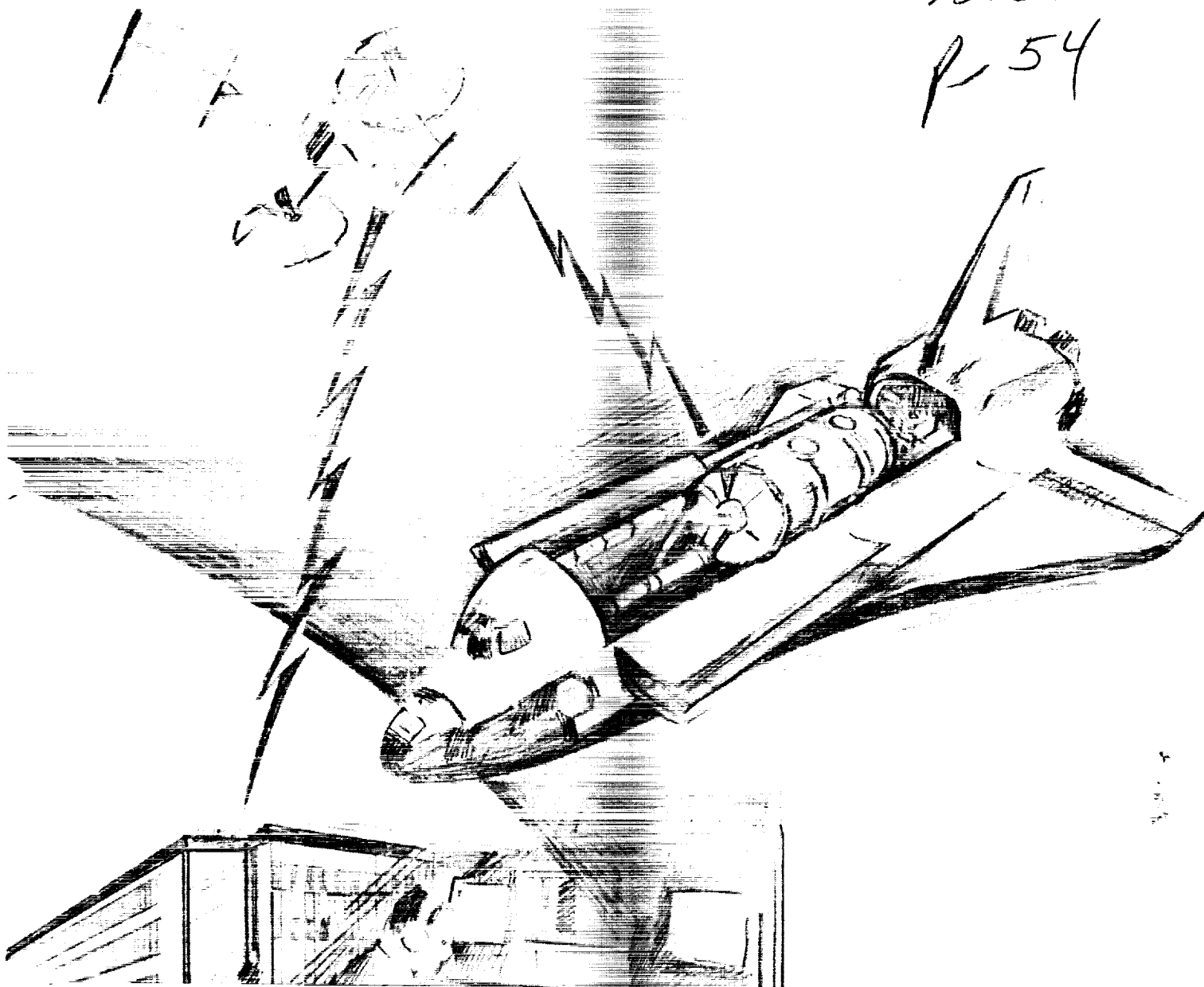
Major NASA Satellite Missions and Key Participants

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p. 54



(NASA-TM-105534) MAJOR NASA
SATELLITE MISSIONS AND KEY
PARTICIPANTS, VOLUME 3 (NASA)
54 p

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NASA

National
Aeronautics and
Space
Administration

is relayed from the Shuttle via the Tracking and Data Relay
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mbelt, MD.

Front Cover: Spacelab data
Satellite Sys
Center, Gree

rk in Spacelab module.

Back Cover: Scientists wo

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INFRARED ASTRONOMICAL SATELLITE (IRAS)

Launch Vehicle — Delta 3910

Project Objective — The Infrared Astronomical Satellite (IRAS) was a joint project of the United States (NASA), the Netherlands, and the United Kingdom. The basic goal of this planned 1-year mission was to obtain a full sky survey over the approximate wavelength range 8 to 120 micrometers with four broadband photometry channels.

Spacecraft Description — IRAS weighed 1,077 kilograms (2,374 pounds), carrying an array of instruments designed to investigate a variety of phenomena in the universe, including unexplained celestial objects and rings of dust within the solar system. The cylindrical satellite was about the size of a passenger van, measuring 3.6 meters (12 feet) in length and 2.16 meters (7 feet) in diameter. Its main component, a 57-centimeter (22.4-inch) Ritchey-Chretien-type reflecting telescope, had an array of infrared detectors mounted at the focal plane. At its base, the telescope was attached to a Dutch-built spacecraft bus that contained all the electronic "housekeeping" equipment for computing, power distribution, tape recording, communications, and telescope pointing control. A large visor-like sun shade reduced the amount of stray light reaching the telescope, and two solar panels acquired sunlight for converting to electricity.

Spacecraft Payload — IRAS carried a highly sensitive, cryogenically-cooled infrared astronomical telescope, which conducted the all-sky survey of objects in the universe that radiate infrared energy. Its detectors were cooled to about 2.5 degrees above absolute zero temperature (2.5 Kelvin, -270 degrees Celsius or -455 degrees Fahrenheit) by superfluid helium, making the instrument the coldest man-made object ever flown in Earth orbit.

Project Results — Launched on January 25, 1983, from the Western Test Range, Vandenberg Air Force Base, CA.

The orbiting telescope detected more than 200,000 infrared sources, a fraction of which have not been correlated with previously known objects. Early in the mission, a small region of the sky was scanned repeatedly to provide the IRAS scientists with a basis for understanding the subsequent data. In this so-called "minisurvey," 8,709 sources were detected and confirmed, of which 133 cold, pointlike sources were selected for further study. Most of these could be either correlated with already known objects or otherwise identified. Nine objects remained in uncrowded regions of the sky, however, which could not be correlated with known sources; nor could evidence be found that they had been detected previously in any other sky survey.

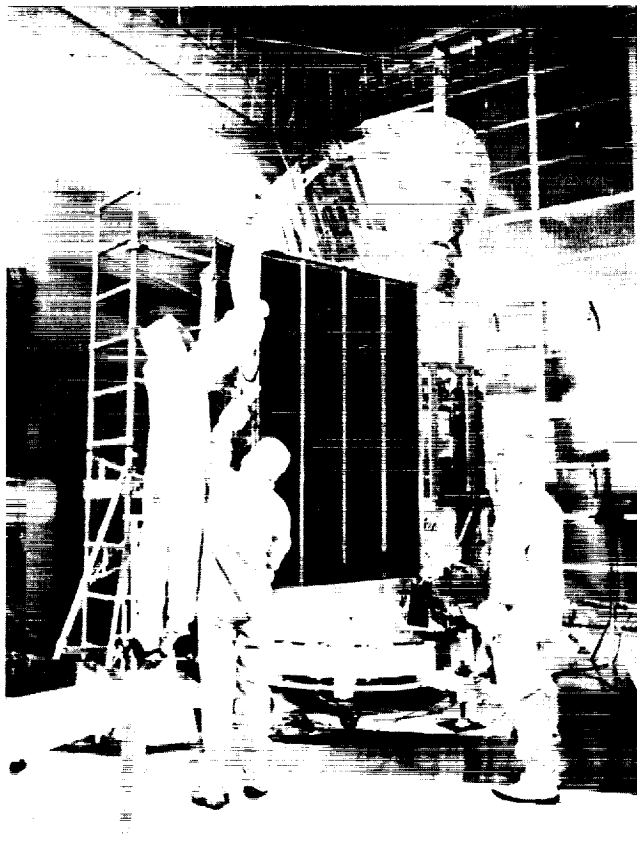
IRAS also discovered three narrow, continuous rings of dust within the solar system. These new features of the solar system may be the result of countless asteroid collisions in the main belt between Mars and Jupiter at a distance from 2.3 to 3.3 astronomical units (200 to 300 million miles) from the Sun. A single catastrophic collision between two solar system objects, such as between asteroids might have produced the two outer bands of material, scientists theorize.

IRAS mapped infrared emission from this interplanetary dust at wavelengths from 12 to 100 microns. (One micron is 1/25,000 inch.) The dust also is known as the zodiacal dust because it lies mainly in the zodiacal or ecliptic plane in which the planets travel. IRAS found that much of interstellar space is littered with wispy clouds of dust, termed "infrared cirrus" which are believed attributable to dust particles found in interstellar space within our Milky Way Galaxy. The spacecraft also has found numerous small clouds of molecular gas and dust that are sites of formation for stars like the Sun within 650 light-years of Earth.

The IRAS all-sky survey found that many nearby dark clouds harbor newly-formed stars in a stage of evolution much like that of the Sun when it formed 4.6 billion years ago.

In addition, IRAS discovered five new comets, detected extensive envelopes of dust around comets not previously known to be dusty and observed a long, thin, invisible trail of cometary debris from the well-known comet Tempel 2.

Major Participants — Program Manager, D. Wrublik, NASA Headquarters, Washington, DC; Program Scientist, N. W. Boggess, NASA Headquarters; Project Manager, G. F. Squibb, NASA-Jet Propulsion Laboratory (JPL), Pasadena, CA; and Project Scientist, H. H. Aumann, NASA-JPL.



U.S. and Dutch technicians prepare Infrared Astronomical Satellite (IRAS) for launch at Vandenberg Air Force Base. The satellite conducted surveys in the infrared portion of the spectrum.

1983

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA-8)

Launch Vehicle — Atlas-E, an Atlas missile that had been refurbished and modified to a standard configuration for use as a launch vehicle for orbital missions. It was capable of launching a spacecraft into a variety of low Earth orbits. The launch vehicle was manufactured by General Dynamics Convair.

Project Objectives — NOAA-8 was designed to transmit data directly to users around the world for local weather analysis. Operational ground facilities included the NOAA Environmental Data Information Services' (NESDIS) Command and Data Acquisition stations in Fairbanks, Alaska, and Wallops Island, Virginia, NESDIS' Satellite Operations Control Center (SOCC) and data processing facilities are in Suitland, Maryland, and a data receiving location, operated by the Etablissement d' Etudes et de Recherches Meteorologiques (EERM) is in Lannion, France.

NOAA-8 carried special instrumentation required to provide a demonstration to Search and Rescue (SAR) mission agencies for evaluation of a satellite-aided SAR system that could lead to the establishment of an operational capability.

That SAR program was a cooperative Canada, France, U.S. and U.S.S.R. effort. The test program began in September 1982, following the launch on June 30, 1982 of the Soviet SAR-equipped navigational satellite Cosmos 1383. Through September 1984 the program had assisted in saving more than 300 lives.

Spacecraft Description — A 1,712-kilogram (3,775-pound) spacecraft, was the fifth in a series of eight satellites developed to give scientists the most comprehensive meteorological and environmental information since the start of the Nation's space program. The satellite series was produced under a \$125 million contract at RCA Astro-Electronics, a unit of the company's Government Systems Division, to build three NOAA Spacecraft.

Spacecraft Payload — Primary instruments carried by NOAA-8 included:

- Advanced Very High Resolution Radiometer (AVHRR) provided by International Telephone and Telegraph (ITT), for measuring energy emitted from the atmosphere in the infrared spectral band.
- Microwave Sounding Unit (MSU), provided by the Jet Propulsion Laboratory (JPL), to measure energy from the troposphere.
- Stratospheric Sounding Unit (SSU), provided by the United Kingdom, to make temperature measurements in the upper atmosphere.
- Space Environmental Monitor (SEM), provided by Ford Aeronautics Communications Corporation (FACC), to measure the population of the Earth's radiation belts and the particle precipitation phenomena resulting from solar activity.
- ARGOS Data Collection System (DCS), provided by France, to collect data from buoys, balloons and remote weather stations.

- Search and Rescue (SAR), with repeater furnished by Canada and the processor provided by France, to detect and locate distress signals.

In addition, a dummy Earth Radiation Budget Experiment (ERBE), provided by TRW, and a dummy Solar Backscatter Ultraviolet Spectral Radiometer (SBUV/2) provided by Ball Aerospace Division (BASD), were flown on NOAA-8 for reasons of weight and balance.

Project Results — Launched March 28, 1983 from Western Space and Missile Center, Vandenberg A.F.B., CA; however, on July 13, 1984 the satellite was reported tumbling. As of September 26, 1984 the satellite was still tumbling and controllers had no hope for recovery.

Major Participants — NASA, NOAA, ASTRO - Electronics Division, RCA (prime contractor for the spacecraft), U.S.A.F. launch support: Program Manager, J. R. Greaves, NASA Headquarters, Washington, DC; Project Manager, G. W. Longanecker, NASA/Goddard Space Flight Center (GSFC), Greenbelt, MD; Project Scientist, A. Arking, NASA/GSFC.

Operation Environmental Monitor

Principal Investigator, H. Leinbach, NOAA - Environmental Research Laboratory (ERL), Boulder, CO; Principal Investigator, H. H. Sauer, NOAA-ERL; Principal Investigator, D. S. Evans, NOAA-ERL.

Advanced High Resolution Radiometer

Principal Investigator
Environmental Satellite Data Information Services
(NESDIS)
Washington, DC.

TIROS Operational Vertical Sounder

Principal Investigator, NESDIS Staff.

Data Collection System

Principal Investigator, NESDIS Staff.

Search and Rescue

Principal Investigator, NESDIS Staff

Instrumentation and their manufacturers included:

- Advanced Very High Resolution Radiometer (ITT)
- High Resolution Infrared Radiation Sounder (ITT)
- Microwave Sounding Unit (JPL)

- Search and Rescue (SAR)
 - SAR Repeater (Communications Research Council (CRC)/Canada)
 - SAR Processor (Centre National d'Etudes Spatiales (CNES)/France)
- Stratospheric Sounding Unit (United Kingdom)
- Space Environment Monitor (Ford Aeronautics Communications Corporation) (FACC, Palo Alto, CA)
- ARGOS Data Collection System (CNES/France)
- ERBE-Scan and Nonscan (TRW, Redondo Beach, CA)
- SBUV (Ball Aerospace Systems Division (BASD), Boulder, CO)

SPACE TRANSPORTATION SYSTEM (STS-6)/ TRACKING AND DATA RELAY SATELLITE (TDRS-A)

Launch Vehicle — Space Shuttle Challenger, built by Rockwell International, Downey, CA.

Program Overview — Space Shuttle is a true aerospace vehicle. It takes off like a rocket, maneuvers in Earth orbit like a spacecraft, and lands like an airplane. The Space Shuttle is designed to carry heavy loads into Earth orbit. Other launch vehicles have done this. But unlike the other launch vehicles which were used just once, each Space Shuttle Orbiter may be used again and again.

Moreover, Shuttle permits check-out and repair of unmanned satellites in orbit, or return of the satellites to Earth for repairs that could not be done in space. Satellites that the Shuttle can orbit and maintain include those involved in environmental protection, energy, weather forecasting, navigation, fishing, farming, mapping, oceanography, and many other fields useful to man.

Interplanetary spacecraft can also be placed in orbit by the Shuttle, together with a rocket stage called the Inertial Upper Stage (IUS) which is being developed by the Department of Defense. After the IUS and spacecraft are checked out, the IUS is ignited to accelerate the spacecraft into deep space. The IUS also will be employed to boost satellites to higher orbits than the Shuttle's maximum altitude - about 1,000 kilometers (approximately 600 miles).

The Shuttle is a manned spacecraft, but unlike the manned spacecraft of the past, such as Mercury, Gemini, and Apollo, it touches down like an airplane on a landing strip. Thus, the Shuttle eliminates the need for the expensive sea recovery force required for Mercury, Gemini, and Apollo. In addition, unlike the previous manned spacecraft, the Shuttle is reusable.

The Shuttle quickly can provide a vantage point in space for observations of transient astronomical events or of sudden weather, agricultural, or environmental crises. Information from Shuttle observations could contribute to sound decisions for countries dealing with such problems.

The Space Shuttle flight system is composed of the orbiter, an external tank (ET) that contains the ascent propellant to be used by the orbiter main engines, and two solid rocket boosters (SRB's). Each booster rocket has a sea level thrust of 11.6 million newtons (2.6 million pounds). The orbiter and SRB's are reusable; the external tank is expended on each launch.

The orbiter is the crew and payload carrying unit of the Shuttle system. It is 37 meters (122 feet) long and 17 meters (57 feet) high, with a wingspan of 24 meters (78 feet) and weighs about 68,000 kilograms (150,000 pounds) without fuel. It is about the size and weight of a DC-9 commercial air transport.

The orbiter can transport a payload of 29,500 kilograms (65,000 pounds) into orbit. It carries its cargo in a cavernous payload bay 18.3 meters (60 feet) long and 4.6 meters (15 feet) in diameter. The bay is flexible enough to provide accommodations for unmanned spacecraft in a variety of shapes and for fully-equipped scientific laboratories.

The orbiter's three main liquid-rocket engines each has a thrust of 2.1 million newtons (470,000 pounds). They are fed propellants from the external tank which is 47 meters (154 feet) long and 8.7 meters (28.6 feet) in diameter.

At liftoff, the tank holds 703,000 kilograms (1,550,000 pounds) of propellants, consisting of liquid hydrogen (fuel) and liquid oxygen (oxidizer). The hydrogen and oxygen are in separate pressurized compartments of the tank. The external tank is the only part of the Shuttle system that is not reusable.

The crew and passengers occupy a two-level cabin at the forward end of the orbiter. The crew controls the launch, orbital maneuvering, atmospheric entry, and landing phases of the mission from the upper-level flight deck. Payload handling is accomplished by crewmen at the aft cabin payload station. Seating for passengers and a living area are provided on the lower deck. The cabin will have a maximum of utility; mission flexibility is achieved with a minimum of volume, complexity, and weight. Space flight will no longer be limited to intensively-trained, physically-perfect astronauts but will accommodate experienced scientists and technicians.

Crew members and passengers will experience a designed maximum gravity load of only 3g during launch and less than 1.5g during a typical reentry. These accelerations are about one-third the levels experienced on previous manned flights. Many other features of the Space Shuttle, such as a standard sea-level atmosphere, will welcome the nonastronaut space worker of the future.

The Space Shuttle mission begins with the installation of the mission payload into the orbiter payload bay. The payload will be checked and serviced before installation and will be activated on orbit. Flight safety items for some payloads will be monitored by a caution and warning system.

In a typical Shuttle mission which lasts from 7 to 30 days, the orbiter's main engines and the booster ignite simultaneously to rocket the Shuttle from the launch pad. Launches are from the John F. Kennedy Space Center in Florida for east-west orbits, or Vandenberg Air Force Base, California, for polar or north-south orbits.

At a predetermined point, the two unmanned solid-rocket booster separate from the orbiter and parachute to the sea where they are recovered for reuse. The orbiter continues into space. It jettisons its external propellant tank just before orbiting. The external tank enters the atmosphere and breaks up over a remote ocean area.

In orbit, the orbiter uses its orbital maneuvering subsystem (OMS) to adjust its path, for rendezvous operations and, at the end of its mission, for slowing down so as to head back toward Earth.

OMS propellants are monomethyl hydrazine as the fuel and nitrogen tetroxide as the oxidizer. They ignite on contact eliminating the need for ignition devices.

The orbiter does not necessarily follow a ballistic path to the ground as did predecessor manned spacecraft. It has a crossrange capability (can maneuver to the right or left of its entry path) of about 2,035 kilometers (1,270 miles).

The orbiter touches down like an airplane on a runway at Kennedy Space Center or Edwards Air Force Base. Landing speed is about 335 kilometers per hour (212 to 226 miles per hour).

The Shuttle crew can include as many as seven people: the commander, the pilot, the mission specialist who is responsible for management of Shuttle equipment and resources supporting payloads during the flight, and one to four payload specialists. The commander, pilot, and mission specialist are NASA astronauts. Payload specialists conduct the experiments and may or may not be astronauts. They are nominated by the payload sponsor and certified for flight by NASA.

NASA's Lyndon B. Johnson Space Center, Houston, Texas, manages the Space Shuttle program and is also responsible for development, production, and delivery of the orbiter.

NASA's Goddard Space Flight Center is responsible for space communications.

NASA's George C. Marshall Space Flight Center, Huntsville, Alabama, is responsible for the development, production, and delivery of the solid rocket booster, the external propellant tank and the orbiter main engines. Test firings of Shuttle engines are carried out at NASA's National Space Technology Laboratories, Bay St. Louis, Mississippi.

NASA's John F. Kennedy Space Center, Florida, is responsible for design and development of launch and recovery facilities and for operational missions requiring easterly launches.

Thousands of companies make up the Shuttle contractor team. They are located in nearly every state of the United States.

Project Objectives — Challenger was the second of four planned operational orbiters to be built. Unlike Columbia, Challenger had no ejection seats. All four crew members were seated on the flight deck during launch and landing. There had been an overall weight reduction in the orbiter of about 1,089 kilograms (2,400 pounds), and Challenger's upgraded controls and displays included a Heads Up Display landing system. Important landing information was viewed by the commander and pilot on a special see-through glass in front of the cockpit window. Several changes had been made to the Challenger's thermal protection system. More than 600 thermal tiles had been replaced by a blanket-like material. All 30,000 tiles had been specially treated (densified) to improve their durability.

The first lightweight external tank flew on STS-6. The tank was approximately 4,500 kilograms (10,000 pounds) lighter than the external tank used on the first flight of the Space Shuttle. Lighter weight solid rocket booster casings saved an estimated 4,000 kilograms (8,000 pounds).

In addition to the weight savings in the orbiter, the Space Shuttle main engines performed at 104 percent of rated-power-level as compared to 100 percent for the main engines aboard Columbia. In terms of thrust developed at sea level, this was an increase of about 15,000 pounds of thrust for each of Challenger's three main engines compared to Columbia's engines.

A significant objective of this mission was the launch-from-space of the world's largest operational communications satellite: The Tracking and Data Relay Satellite (TDRS) (see Spacecraft Payload). An Air Force-developed Inertial Upper Stage (IUS) was to be used to boost the satellite to an altitude of 36,000 kilometers (22,300 miles) above the equator. TDRS-A (TDRS-1 in orbit) was to be the first of three similar satellites to be deployed and used for Space Shuttle and other NASA space communications requirements.

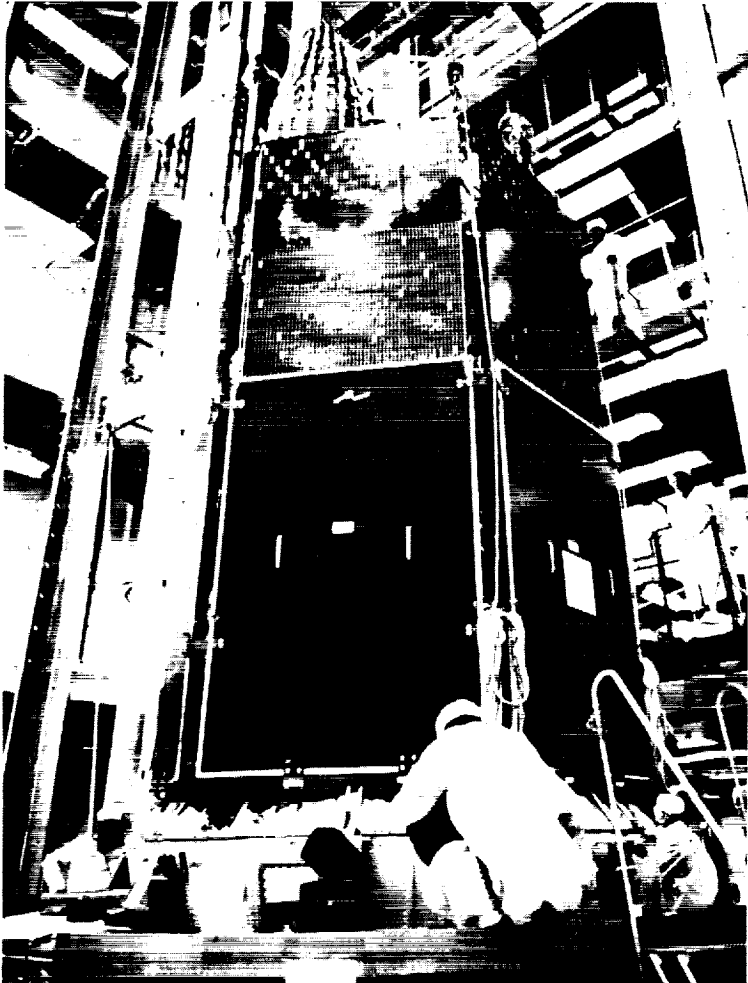
The flight crew of STS-6 was Commander Paul J. Weitz, 50, and Karol J. Bobko, 45, pilot. Mission specialists were Donald H. Peterson, 49, and Dr. Story Musgrave, 47.

Spacecraft Payload — Tracking and Data Relay Satellite-A. TDRS-A was the first of three identical spacecraft planned for the TDRS system (TDRSS). The system was developed following studies in the early 1970s which showed that a system of telecommunication satellites operated from a single ground station could better support the Space Shuttle and other planned scientific and application mission requirements. At the same time, this would also help to halt the spiraling cost escalation of upgrading and operating a worldwide tracking and communications network of ground stations.

In addition to the Space Shuttle, the TDRSS was equipped to support up to 26 user satellites simultaneously and to provide two basic types of service: a multiple access service which could relay data from as many as 20 low data rate user satellites simultaneously, and a single access service which could provide two high data rate communication relays.

The TDRS spacecraft was to be deployed from the orbiter Challenger approximately 11 hours after launch. Transfer to geosynchronous orbit was to be provided by the solid propellant Inertial Upper Stage (IUS). Separation from the upper stage was to occur approximately 17 hours after launch. Required Earth pointing for TDRS commands and telemetry, plus thermal control maneuvers, was to be done by the upper stage between first and second stage burns.

Deployment of the solar panels, C-band antenna and space ground link antenna, was to occur prior to TDRS separation from the upper stage. The single access parabolic antenna was to deploy after separation and subsequent to acquisition of the Sun and Earth by spacecraft sensors utilized for attitude control. Attitude and velocity adjustments were to place the TDRS into its final geostationary



NASA's Tracking and Data Relay Satellite is being mated to its upper stage which will propel it into a geosynchronous orbit after being ejected from Challenger's cargo bay during STS-6.

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*And there she goes!
TDRS leaves the cargo bay.*



1983

position. The TDRS was three-axis stabilized with the body fixed antennas pointing constantly at the Earth while the solar arrays track the Sun.

The existing NASA ground station network (evolved since the beginning of the U.S. space program) was capable of providing communications support for only a small fraction (typically 15 percent) of the orbital period. The new TDRSS network, when operational, should provide coverage for almost the entire orbital period of a user spacecraft. However the TDRSS does no processing of user traffic, in either direction. It operates as a "bent-pipe" repeater, relaying signals and data between the user spacecraft and ground terminal.

A TDRSS ground terminal had been built at White Sands, N.M., which provided a location at a longitude with a clear line-of-sight to the TDRS satellites and a place where rain conditions do not interfere with the availability of the K-band uplink and downlink channels.

Also located at White Sands was the NASA Ground Terminal (NGT), which provided the interface between the TDRSS and the other TDRSS network elements which had their primary tracking and communication facilities at Goddard Space Flight Center. Located at Goddard were the Network Control Center (NCC), which provides system scheduling and is the focal point for NASA communications with the TDRSS and the other TDRSS network elements; the Operating Support Computing Facility (OSCF), which furnishes the network with orbital predictions and definitive orbit calculations for user spacecraft and the TDRS; and the NASA Communications Network (NASCOM), which provides the common carrier interface at network locations and consists of domestic satellites and their interface through Earth terminals at Goddard, White Sands, and the Johnson Space Center in Houston, Texas.

TDRS-A measured more than 17.4 meters (57 feet) across when the solar panels were fully extended. Two single access antennas each measured 4.9 meters (16 feet) in diameter and when deployed in space measured more than 12.9 meters (42 feet) from tip to tip.

TDRS is the largest and most advanced communications satellite ever launched. Each weighs about 2,200 kilograms (4,668 pounds) in orbit and measures 17 meters (57 feet) across the solar panels. Operating in the S-band and Ku-band frequencies, their complex electronic relay system was designed to handle up to 300 million bits of information each second from a single user spacecraft. The TDRS satellites have a design life of 10 years. TDRS-A was stationed over the northeast corner of Brazil at 41 degrees West Longitude. Another is to be positioned southwest of Hawaii at 171 degrees West Longitude, and the third—an in-orbit spare is scheduled to be located over the United States between the two others.

Other Payloads — Other STS-6 experiments included a reflight of the Continuous Flow Electrophoresis system (CFES), flown earlier on STS-4. The system was in a module attached to the left middeck wall where food galleys later are to be fitted in orbiters.

Additional experiments were the Monodisperse Latex Reactor (MLR) and Nighttime/Daytime Optical Survey of Lightning (NOSL). Three Get Away Special (GAS) canisters in the payload bay contained experiments flown by the U.S. Air Force Academy, Park Seed Co., and Asahi Shimbun, a Japanese newspaper.

In addition to the payloads and experiments, two life sciences detailed test objectives were included: the study of and countermeasures for space motion sickness, and cardiovascular deconditioning countermeasures.

Project Results — The mission began on April 4, 1983 from Kennedy Space Center, FL and ended on April 9, 1983 with a landing at Edwards Air Force Base, CA. Its orbital elements were 293 kilometers apogee (182 miles) and 284 kilometers (176 miles) perigee.

TDRS was released from the orbiter cargo bay as planned. However the Inertial Upper Stage (IUS) second stage engine firing failed to place it in its final 35,888-kilometer (22,300-mile) geosynchronous orbit. Launch officials were confident they could achieve its planned orbit in a matter of weeks and they did.

Other mission chores included a spacewalk in which crew members practiced using tools and equipment-handling techniques in the cargo bay. These procedures were preparatory to making repairs to an ailing Earth satellite.

In the first spacewalk by American astronauts in more than 9 years, Story Musgrave and Donald Peterson moved out of the Challenger's airlock at 4:20 p.m. April 7. Their activities outside the spacecraft cabin were completed during the 51st, 52nd and 53rd orbits at 17,500 miles per hour and 284 kilometers (177 miles) above the Earth. They were viewed on television during a pass from the Pacific Ocean to the Gulf of Mexico. As they went about their tasks in the cargo bay, the astronauts seemed to move well despite their 15-meter (50-foot) restraining tethers. They attached these lines to fixed guide cables stretched along each side of the open compartment.

Before they left the airlock, Musgrave and Peterson spent 3 hours breathing pure oxygen to purge the nitrogen from their blood. This procedure was required to avoid the "bends" experienced by divers and space travelers when they undergo compression or decompression too rapidly.

Just before they began their spacewalk, President Ronald Reagan placed a radio telephone call to the crew. "Please know that all of us, the American people, are proud of your service to your country and what you're doing," he said.

Peterson and Musgrave were the 28th and 29th Americans to walk in space—the first since February 1974 when astronauts in the Skylab crew "went outside" to retrieve film canisters from some of the orbiting laboratory's optical equipment.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. James A. Abrahamson, Associate Administrator for Space Flight; Jesse W. Moore, Deputy Associate Administrator for Space Flight; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Robert O. Aller, Director, Tracking and Data Relay Satellite System Division; Lorne M. Robinson, Associate Director, TDRSS Program; Eugene Ferrick, Chief, TDRSS Operations.

Dryden Flight Research Facility, Edwards, CA

John Manke, Facility Manager; Gary Layton, Shuttle Project Manager.

Goddard Space Flight Center, Greenbelt, MD

Richard S. Sade, Director of Networks; Gilbert Branchflower, Deputy Director for TDRSS; Ronald K. Browning, TDRSS Program Manager.

Johnson Space Center, Houston, TX

Glynn S. Lunney, Manager, Space Shuttle Program.

Kennedy Space Center, Cape Canaveral, FL

Thomas E. Utzman, Director, Shuttle Management and Operations; Thomas S. Walton, Director, Cargo Management and Operations.

Marshall Space Flight Center, Huntsville, AL

Robert E. Lindstrom, Manager, Shuttle Projects Office.

Space Communications Co., Gaithersburg, MD

Edwin A. Coy, Vice President, TDRSS Program Manager; William J. Koselka, Vice President, Operations.

RADIO CORPORATION OF AMERICA RCA-F

Launch Vehicle — The second launch of a Delta 3924 vehicle. The three stage Delta vehicle consisted of: an extended long tank first stage with Rocketdyne RS-27 engine and nine Castor IV strap-on solid motors for the first stage; the new improved Aerojet AJ10-118k second stage and a Thiokol TE-364-4 third stage engine. The entire vehicle was 2.4 meters (8 feet) in diameter (excluding the strap-on solid motors) and 353.57 meters (116 feet) in height.

Project Objective — This satellite was to replace the first of RCA's domestic communications satellites launched December 12, 1975. It was to be placed at 139 degrees West Longitude, 35,888 kilometers (22,300 miles) above the Equator. RCA-F was to provide communication services to government and commercial customers in the United States.

RCA-F joined five other previous RCA communications satellites in orbit. The satellites provide coverage for all 50 states, the District of Columbia and Puerto Rico with television, voice channels and high-speed data transmission. There are more than 4,000 Earth stations with direct access to these spacecraft.

RCA American Communications, Inc. (Americom), Princeton, NJ, was responsible for the management of the RCA Satellite Communication Program including acquisition of the spacecraft, associated tracking, telemetry, command systems and launch vehicle support. Spacecraft development and production were the responsibility of RCA's Astro Electronics Division, Princeton.

Spacecraft Description — With solar panels deployed, the satellite spanned 4.72 meters (15.5 feet). Its on-orbit weight was 598.6 kilograms (1,320 pounds).

The three-axis stabilized spacecraft was equipped with the power, attitude control, thermal control, propulsion, structure and command, ranging and telemetry necessary to support mission operations from booster separation through 10 years in geosynchronous orbit, its designed spacecraft life.

Spacecraft Payload — The satellite carried 24 active solid state transponders.

Project Results — Launched from Cape Canaveral Air Force Station, FL, on April 11, 1983.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. J. A. Abrahamson, Associate Administrator for Space Flight; Joseph B. Mahon, Director, Expendable Launch Vehicle Program; Peter Eaton, Manager, Delta Program; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems.

Goddard Space Flight Center, Greenbelt, MD

William E. Keathley, Director, Flight Projects Directorate; Robert C. Baumann, Acting Delta Project Manager; William A. Russell, Jr., Deputy Delta Project

Manager; John D. Kraft, Manager, Delta Mission Analysis and Integration; Richard H. Schlafford, RCA Satcom 1R Mission Integration Manager; Robert Seiders, RCA Satcom 1R Network Support Manager; Ralph Banning, Network Director.

Kennedy Space Center, Cape Canaveral, FL

Thomas S. Walton, Director, Cargo Operations; Charles D. Gay, Director, Expendable Vehicles Operations; D. C. Sheppard, Chief, Automated Payloads Division; Wayne L. McCall, Chief, Delta Operations Division; David Bragdon, Spacecraft Coordinator.

RCA American Communications, Inc., Princeton, NJ

John Christopher, Vice President of Technical Operations; Joseph Schwarze, Director, Space Systems; William Palme, Manager, Advanced Space Programs; Joseph Elko, Manager, Spacecraft Engineering.

Contractors

RCA American Communications, Inc., Astro Electronics Div., Princeton, NJ, Spacecraft management development/production; McDonnell Douglas Astronautics Co., Huntington Beach, CA, Delta Launch Vehicle; Rocketdyne Division, Rockwell International, Canoga Park, CA, First stage engine (RS-27); Thiokol Corp., Huntsville, AL, Castor IV strap-on solid fuel motors; Aerojet Liquid Rocket Co., Sacramento, CA, AJ10-118k second stage; Thiokol Corp., Elkton, MD, TE364-4 third stage engine.

Major Subcontractors

SPAR Aerospace Division, Ste-Anne-de-Bellevue, Quebec, Canada, Antenna Input and Output; Charles Stark Draper Labs, Cambridge, MA, Momentum Wheel Assembly; Lockheed Space Systems Div., Sunnyvale, CA, Earth Sensor Assembly and Horizon Sensor Assembly; Thiokol Corp., Elkton, MD, Apogee Kick Motor (Star 30) in spacecraft; Hughes Aircraft Co., Electro Dynamics Division, Torrance, CA, Traveling Wave Tube Amplifiers; Rocket Research, Redmond, WA, Reaction Engine Assembly; Cubic Corp., Defense System Division, San Diego, CA, Beacon Transmitter and Command Receiver; Parsons of California, Stockton, CA, Structure and Solar Panels; Adcole Corp., Waltham, MA, Sun Sensor Assembly; Northrop Corp., Norwood, MA, Rate Measuring Assembly.



A new 24-channel domestic communications satellite, RCA-F is being checked out prior to launch.

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE (GOES-6)

Launch Vehicle — Delta, 116 feet (35.5 meters) tall. The main engine was assisted by nine solid-fueled boosters.

Project Objectives — GOES-6 was the sixth in a series of NASA-developed, NOAA-operated spacecraft to obtain data on the Earth's atmospheric system, weather, temperature, cloudcover, and other data.

Spacecraft Description — The cylindrically-shaped spacecraft measured 190.5 cm (75 inches) in diameter and 230 cm (90 inches) in length, exclusive of a magnetometer that extended an additional 83 cm (32 inches) beyond the cylindrical shell. The primary structural members were a honeycombed equipment shelf and a thrust tube. The Visible Infrared Spin Scan Radiometer (VISSR) telescope was mounted on the equipment shelf and viewed the Earth through a special aperture in the side of the spacecraft. A support structure extended radially from the thrust tube and was affixed to the solar panels, which formed the outer wall of the spacecraft to provide the primary source of electrical power. Located in the space between the thrust tube and the solar panels were stationkeeping and dynamics control equipment, batteries, and most of the Space Environment Monitor (SEM) equipment.

Spacecraft Payload — The spin-stabilized, Earth-synchronous spacecraft carried (1) a Visible Infrared Spin Scan Radiometer (VISSR) atmospheric sounder to provide high-quality, day/night cloud cover data, to take radiance temperatures of the Earth's atmospheric system, and to determine atmospheric temperature and water vapor content at various levels, (2) a meteorological data collection system to relay processed data from central weather facilities to regional stations equipped with small Automatic Picture Transmission (APT) facilities and to collect and retransmit data from remotely located Earth-based platforms, and (3) a Space Environment Monitor (SEM) system to measure proton, electron, and solar X-ray fluxes and magnetic fields.

Proper spacecraft attitude and spin rate (approximately 100 rpm) were maintained by two separate sets of jet thrusters mounted around the spacecraft's circumference and activated by ground command. The spacecraft used both Ultra High Frequency (UHF)-band and S-band frequencies in its telemetry and command subsystem. A low-power Very High Frequency (VHF) transponder provided telemetry and command during launch and then served as a backup for the primary subsystem once the spacecraft attained synchronous orbit.

Project Results — Launched into a geosynchronous orbit from Cape Canaveral Air Force Station, FL on April 28, 1983.

Major Participants —

Energetic Particle Monitor

Principal Investigator, H. Leinbach, NOAA - Environmental Research Laboratory (ERL), Boulder, CO; Principal Investigator, H. H. Sauer, NOAA - ERL.

Solar X-Ray Monitor

Principal Investigator, H. Leinbach, NOAA-ERL; Principal Investigator, H. H. Sauer, NOAA-ERL.

Magnetic Field Monitor

Principal Investigator, H. Leinbach, NOAA - ERL; Principal Investigator, H. H. Sauer, NOAA - ERL; Other Investigator, J. N. Barfield, Southwest Research Institute, Dallas, TX.

Visible Infrared Spin-Scan Radiometer, Atmospheric Sounder

Principal Investigator, Staff, NOAA - National Environmental Satellite Data Information Service (NESDIS), Washington, DC; Other Investigator, W. E. Shenk, NASA - Goddard Space Flight Center, Greenbelt, MD.

Data Collection System

Principal Investigator, Staff, NOAA - NESDIS.



The Geostationary Operational Environmental Satellite (GOES-6) being prepared for launch. It was the third in a series of improved weather observers.

INTELSAT V-F

Launch Vehicle — Launched by the Atlas Centaur, NASA's standard launch vehicle for intermediate weight payloads. The launch vehicle had the following general characteristics: height: 40.8 meters (134 feet) including nose fairing; diameter: 3.05 meters (10 feet); total liftoff weight: 148,285 kilograms (326,907 pounds) including spacecraft; liftoff thrust: 1,936,196.5 newtons (435,296 pounds) sea level.

NASA's Lewis Research Center had management responsibility for Atlas Centaur development and operation. Intelsat V-F marked the 100th launch by engineers of Lewis Research Center, a NASA facility near Cleveland, Ohio.

Project Objectives — Intelsat V-F was the sixth of a new series of 9 international telecommunications satellites owned and operated by the 105-nation International Telecommunications Satellite Organization (Intelsat). Five earlier Intelsat Vs had been launched successfully by NASA in December 1980, May 1981, December 1981, March 1982, and September 1982.

This was the first Intelsat to incorporate a maritime communication system for ship-to-shore communications. It was to be positioned in geosynchronous orbit over the Atlantic Ocean as a major satellite to provide communications services between Europe and North America.

Spacecraft Description — Intelsat V-F weighed 1,996 kilograms (4,400 pounds) at launch and had almost double the communications capability of earlier satellites in the Intelsat series.

Spacecraft Payload — Twelve thousand voice circuits and two color television channels. Intelsat V satellites were built by the Ford Aerospace and Communications Corp, Palo Alto, CA, using system components developed by firms in the United Kingdom, France, the Federal Republic of Germany, Italy, and Japan.

Project Results — Launched into geosynchronous orbit from Cape Canaveral Air Force Station, FL, on May 19, 1983.

The Atlas Centaur placed the Intelsat V-F into a highly elliptical transfer orbit 166.8 kilometers perigee altitude by 35,807.4 kilometers apogee altitude (103.6 by 22,253.5 miles). From this orbit, at apogee, a solid propellant rocket motor attached to the satellite was fired, circularizing the orbit at geosynchronous altitude 35,888 kilometers (22,300 miles) over the equator.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. James A. Abrahamson, Associate Administrator for Space Flight;
Joseph B. Mahon, Director, Expendable Launch Vehicles; F. R. Schmidt,
Manager, Atlas Centaur Launch Vehicle.

Lewis Research Center, Cleveland, OH

Lawrence J. Ross, Director, Space Flight Systems; John Gibb, Atlas Centaur Project Manager; S. V. Szabo, Jr., Chief, Space Transportation Engineering Division; Richard E. Orzechowski, Intelsat Mission Project Engineer.

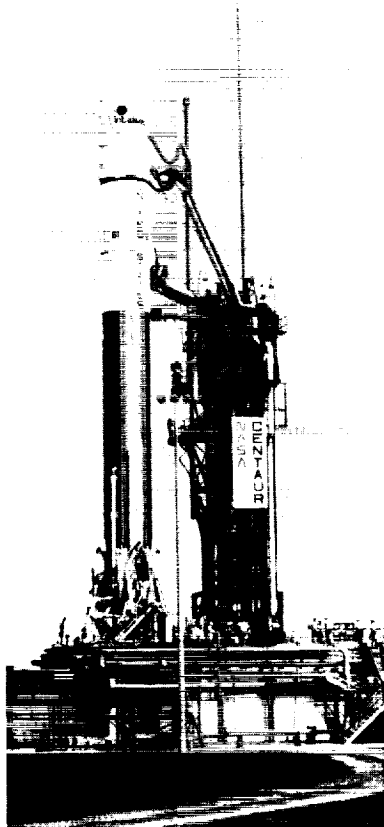
Kennedy Space Center, Cape Canaveral, FL

Thomas S. Walton, Director, Cargo Operations; Charles D. Gay, Director, Expendable Vehicle Operations; D. C. Sheppard, Chief, Automated Payloads Division; James L. Womack, Chief, Atlas Centaur Operations Division; Larry Kruse, Spacecraft Coordinator.

Contractors

General Dynamics/Convair, San Diego, CA, Atlas Centaur Launch Vehicle; Honeywell Aerospace Division, St. Petersburg, FL, Centaur Guidance Inertial Measurement Group; Pratt and Whitney Aircraft Group, West Palm Beach, FL, Centaur RL-10 Engines; Teledyne Industries, Inc., Northridge, CA, Digital Computer Unit/PCM Telemetry; Rocketdyne Division, Rockwell International Corp., Canoga Park, CA, MA-5 Propulsion Systems.

*Intelsat V aboard
Atlas Centaur Launch
Vehicle awaits
evening liftoff (1).
Intelsat V lifts off
from Complex 36,
Pad A.*



EUROPEAN X-RAY OBSERVATORY SATELLITE (EXOSAT)

Launch Vehicle — The three-stage Delta 3914 configuration was used to launch EXOSAT. It was 35.36 meters (116 feet) tall and 2.4 meters (8 feet) in diameter; liftoff weight was approximately 190,631 kilograms (420,270 pounds). Its average first stage thrust was 2,544,256 newtons (572,000 pounds).

Project Objective — The scientific mission of EXOSAT was to measure the position, structural features and spectral and temporal characteristics of cosmic X-ray sources in the approximate range 0.04 to 80 keV. EXOSAT was to use two operational modes: (a) the occultation mode, for the precise determination and identification of sources and the observation of structural features, using primarily the Moon or the Earth as the occulting body, and (b) the arbitrary pointing mode for the study of the temporal and spectral variability of sources over long uninterrupted time intervals and the mapping of low-energy sources. With accurate timekeeping on board, and with the capability of long continuous observation, EXOSAT could determine regular and irregular variations of the intensity of X-ray sources on a time scale ranging from tens of microseconds to tens of hours.

Spacecraft Description — The triaxial- stabilized spacecraft, weighing 510 kilograms (1,125 pounds) was cylindrical in shape. A rotatable solar array covering an area of 3 square meters (9 feet) was mounted on top of the spacecraft. The star trackers were mounted on the optical benches of the two imaging telescopes to facilitate alignment and stability. The observatory was able to view all of the celestial sphere except for a small cone centered on the Sun.

The industrial development of the spacecraft was entrusted to the European Cosmos Consortium, led by the German firm Messerschmitt-Bolkow-Blohm, Munich, the system contractor. Responsibilities at system level covered management, engineering and assembly, integration and test. Subsystem responsibility was shared by 20 European firms.

Spacecraft Payload — The scientific payload consisted of four instruments:

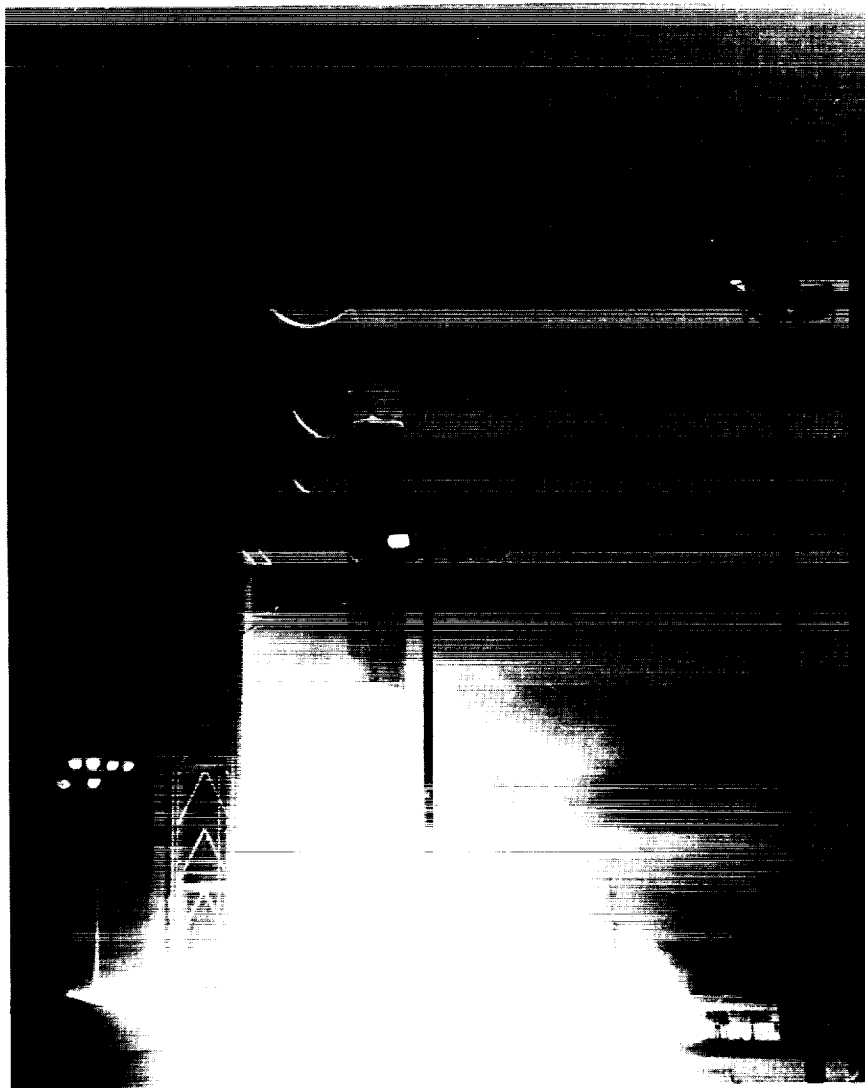
- A medium-energy experiment comprising an array of gas-filled proportional counters, generally similar to detectors flown through the 1970s, but developed using the most up-to-date techniques and methods;
- Two imaging telescopes, similar in function to the telescope flown on the Einstein Observatory and of comparable performance but with lightweight optics, using a new European-developed method of reapplication; and
- A gas scintillator spectrometer which was a newly-developed instrument that would be flown for the first time aboard EXOSAT.

Project Results — Launched from Vandenberg Air Force Base, CA on May 26, 1983. Orbital elements were 191,570 kilometers apogee (119,000 miles), 355 kilometers perigee (220 miles). The observatory, placed in a highly eccentric orbit was capable of observing lunar occultations over 20 percent of the celestial sphere within a year. The positional accuracy of bright sources was limited

by the inaccuracy of measurement of the position of the satellite and the uncertainty of the topography of the lunar limb. For weaker sources, the accuracy was limited by statistics, such as the total number of X-ray quanta received during the time of the corresponding angular displacement of the Moon. When not engaged in occultation observations, the observatory could view the sky uninterrupted in any chosen direction (except 60 degrees about the solar direction) for as long as the orbital period was above the Van Allen radiation belts.

The telemetry data transmitted by EXOSAT was received at the Villafranca ground station in Spain and routed in real time to the European Space Operations Center (ESOC) in Darmstadt, Federal Republic of Germany, where the control center and EXOSAT observatory ground systems were located. Extensive computer and display facilities were available so that part of the data could be processed in real time and displayed immediately.

*Delta 3914 launches EXOSAT
(European X-Ray Observatory
Satellite) from Vandenberg Air
Force Base, CA.*



Major Participants —

European Space Agency (ESA) Council

Chairman; Professor H. Curien (France); Vice Chairman, Dr. H. H. Atkinson (U.K.) and Dr. H. H. Grage (Denmark); Chairman of the Science Program Committee, Professor C. de Jager (The Netherlands).

ESA Directorate

Director General, Erik Quistgaard; Director of Administration, George van Reeth; Director of Application Programs, Edmund Mallett; Director of Spacecraft Operations, Reinhold Steiner; Director of Space Transportation Systems, Michel Bignier; Director of Scientific Programs, Roger-Maurice Bonnet; Technical Director, Massimo Trella.

Scientific Programs Directorate

Scientific Program Coordinator, Vittorio Manno; Head of Scientific Projects Department, Maurice Delahais; EXOSAT Project Manager, Gerhard Altmann; Head of Space Science Department, D. Edgar Page; Head of High Energy Astrophysics Division, Brian Taylor; EXOSAT Project Scientist, Dieter Andresen; Head of Future Projects Office, Gordon Whitcomb.

NASA/Industry Team:

NASA Headquarters, Washington, DC

Lt. Gen. J. A. Abrahamson, Associate Administrator for Space Flight; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Joseph B. Mahon, Director, Special Programs; Peter Eaton, Chief, Expendable Launch Vehicle Programs; Henry Clarks, Delta Program Manager.

Goddard Space Flight Center, Greenbelt, MD

William C. Keathley, Director, Flight Projects Directorate; Robert C. Baumann, Acting Delta Project Manager; William A. Russell, Jr., Deputy Delta Project Manager; J. Donald Kraft, Manager, Delta Mission Analysis and Integration; Frank J. Lawrence, EXOSAT Mission Integration Manager; Robert I. Seiders, Delta Network Support Manager; Karl Schauer, EXOSAT Network Support Manager; Ralph Banning, Network Director.

Kennedy Space Center, Cape Canaveral, FL

Charles D. Gay, Director, Expendable Vehicles Operations; Wayne L. McCall, Chief, Delta Operations Division; Ray Kimlinger, Chief, Western Operations Branch; C. R. Fuentes, Spacecraft Coordinator.

Contractors

McDonnell Douglas Astronautics Co., Huntington Beach, CA, Delta Launch Vehicle; Rocketdyne Division, Rockwell International, Canoga Park, CA, First Stage Engine (RS-27); Thiokol Corp., Huntsville, AL, Castor IV Strap-On Fuel Motors; TRW, Redondo Beach, CA, TR-201 Second Stage Engine; Delco, Santa Barbara, CA, Guidance Computer; Thiokol Corp., Elkton, MD, TE-364-4 Third Stage Motor. _____

Key Spacecraft Personnel

Project Manager, G. Altmann, European Space Agency (ESA); Project Scientist, R. D. Andresen, ESA; Project Scientist, A. Peacock, ESA.

Scientific Investigators:

Low-Energy X-Ray Imaging Telescopes

Team Leader, R. L. F. Boyd (Retired), U. College, London, UK; Team Member, P. W. Sanford, U. College; Team Member, B. N. Swaneburg, U. of Leiden, The Netherlands; Team Member, J. A. M. Bleeker, U. of Leiden; Team Member, C. De Jager, U. of Utrecht, The Netherlands; Team Member, A. C. Brinkman, U. of Utrecht.

Gas Scintillation X-Ray Spectrometer

Team Leader, B. G. Taylor, U. College, London, UK; Team Member, R. D. Andresen, U. College; Team Member, R. L. F. Boyd (Retired), U. College; Team Member, P. W. Sanford, U. College; Team Member, L. Scarsi, U. of Palermo, Italy; Team Member, S. Saleni, U. of Palermo; Team Member, G. Boella, U. of Milan, Italy; Team Member, G. Villa, U. of Milan; Team Member, A. Peacock, ESA-ESTEC.

Medium-Energy Cosmic X-Ray Package

Team Leader, J. Truemper, U. of Tübingen, West Germany; Team Member, H. Zimmerman, U. of Tübingen; Team Member, R. Staubert, U. of Tübingen; Team Member, K. A. Pounds, U. of Leicester, UK; Team Member, M. Turner, U. of Leicester.

STS-7/ANIK C/ PALAPA B

Launch Vehicle — Space Transportation System (STS), Space Shuttle Challenger

Program Overview — See previous STS missions.

Project Objectives — The seventh flight of the Space Shuttle was to be the most ambitious with orbiter Challenger scheduled to deploy two commercial communications satellites and to perform the first landing on the 3-mile-long runway located at NASA's Kennedy Space Center, FL. However, facilities at Edwards Air Force Base, CA, were to serve as backup sites if weather conditions prevented a landing in Florida.

Challenger carried a five-person crew on its second trip into space. Robert L. Crippen was commander of the 6-day mission. Crippen was pilot on the historic 54-1/2 hour maiden flight of the orbiter Columbia in April 1981 and became the first astronaut to make two flights aboard the Shuttle. The STS-7 pilot was Frederick H. Hauck. Mission specialists on this flight were John M. Fabian, Dr. Norman E. Thagard and Dr. Sally K. Ride, who became America's first woman in space.

Dr. Thagard originally was not a member of the STS-7 crew, but was added in December 1982 to conduct medical tests and collect additional data on several physiological changes that are associated with astronauts' adaptation to space. Configuration of the STS-7 Shuttle was very similar to that of the STS-6 vehicle when Challenger became the second in NASA's fleet of reusable spacecraft. Crew size required an additional seat which was installed on the middeck. The other four crew members were seated on the flight deck for launch and landing.

The external tank for this mission was the last of the standard heavyweight tanks. Lighter weight solid rocket booster casings, like those on STS-6, were used, and Challenger's main engines performed at 104 percent of rated power level.

Spacecraft Payload — Challenger sent the Telesat Canada Anik C and the Indonesian Palapa B communications satellites into low Earth orbit for deployment and eventual insertion into geosynchronous orbit. The Anik C satellite was deployed approximately 9½ hours after launch. Palapa B was ejected from Challenger's cargo bay on the second day of the mission as the Shuttle made its 19th revolution of the Earth. Both satellites were similar in design.

A McDonnell Douglas Astronautics Co. (St. Louis, MO)-developed Payload Assist Module (PAM) was used to boost each of the satellites into an elliptical transfer orbit.

Challenger carried the Canadian-built Remote Manipulator System (RMS) or arm back into orbit on STS-7 to perform the first deployment and retrieval exercise with the Shuttle Pallet Satellite (SPAS)—a space platform that could operate either inside or outside the payload bay. On the fourth day of the mission, the robot arm was to place the SPAS outside Challenger's cargo bay where it remained for approximately 9-1/2 hours while Challenger performed a variety of grapple and rendezvous activities.

Carried in the cargo bay was the first U.S./German cooperative materials science payload called OSTA-2 for NASA's Office of Space and Terrestrial Applications.

The crew operated the Continuous Flow Electrophoresis System (CFES) and Monodisperse Latex Reactor (MLR)—two middeck-mounted experiments flown on previous Shuttle missions which were designed to evaluate the gravity-free space environment for developing materials with potential pharmaceutical and medical uses.

Seven small self-contained payloads, "Get Away Specials," also were flown aboard Challenger.

The Anik C spacecraft was Canada's first totally dedicated commercial satellite to use the 12/14 GHz K band frequencies, allowing a 100 percent increase in telecommunications capacity of the first Anik satellite. This Anik C was to be stationed at 112.5 degrees West Longitude and had a design life of 10 years.

Palapa B was the second generation of satellites for Indonesia. The communications satellites were built for PERUMTEL, Indonesia's state-owned telecommunications company.

With its 24 transponders, Palapa B was able to deliver voice, video, telephone and high-speed data services, electronically linking Indonesia's many islands and bringing advanced telecommunications to the nation's 130 million inhabitants. Palapa B was to be stationed at 108 degrees East Longitude.

Project Results — After a smooth and trouble-free countdown, Challenger was launched on time from the Kennedy Space Center's Pad 39A at 7:33 a.m. EDT on June 18, 1983, into a circular orbit at 256 kilometers (159 statute miles) altitude. The accuracy of the vehicle's ascent trajectory was the best yet for a Space Shuttle.

The first order of business after setting up station in orbit was to release the Anik C-2 communications satellite. Approximately 9-1/2 hours into the mission and shortly before the end of their first workday in space, the crew spring-ejected Anik from its spinning platform in the cargo bay and fired Challenger's engines to back the Shuttle away from the satellite. The rocket motor attached to Anik then fired to begin raising it to its 36,000 kilometers (22,300 nautical miles)-high geosynchronous orbit over the equator, where it was used initially for North America's first direct satellite-to-home pay-TV service.

Challenger's second day in orbit featured a nearly identical deployment of the Indonesian Palapa B-1 satellite, which was boosted to its geosynchronous station over the islands of Indonesia. This first in a new series of Indonesian satellites was to be used for many of that nation's telecommunications needs, including video, telephone and data transmission.

By the fourth day of the STS-7 mission, both of these communications satellites had reached their desired high orbits, on time and on target.

With the two commercial satellites successfully delivered, the crew turned to other tasks, including the activation of 7 GSFC-managed Get Away Special canisters—more than any other Shuttle had carried. These varied experiments were designed to test, among other things, the effects of space on the social behavior of an ant colony, on radish seeds, germinating sunflowers, liquid mercury and soldering operations. Two of the canisters featured new Get Away Special technologies, including the first fully automatic experiment (turned on by a barometric switch rather than by the crew) and the first canister with an opening door.

Also on the second day of the mission were the first checkouts of the Ku-band antenna which was to be used for ground communications through the Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit. The antenna's motion and signal acquisition were successful and pronounced ready for operation. GSFC manages the total TDRSS Network from its control center located in Greenbelt.

The crew began its third workday with a test that proved that the cabin air pressure could be reached successfully from 14.7 pounds per square inch (psi) to 10.2 psi by controlling the mix of oxygen and nitrogen in the air. This technique was being considered as an alternative to the 3-hour breathing of pure oxygen that was required before astronauts leave the controlled environment of the Shuttle for space-suited Extra-Vehicular Activity (EVA). Cabin pressures would be dropped while the crew was sleeping to allow a shorter pre-breath time for purging nitrogen from an astronaut's bloodstream prior to a spacewalk, all to avoid the body's painful reaction to fast changes in atmospheric pressure, commonly known as the "bends."

During this 30-hour test, the crew also lowered Challenger's orbit slightly to begin a run of experiments with the Shuttle Pallet Satellite (SPAS-01) mounted in the cargo bay. SPAS was the first Shuttle cargo financed as a private commercial venture by a European company, Messerschmitt-Bolkow-Blohm of Munich. The SPAS concept was to sell space on the platform—a supporting pallet that provides power and computer processing to attached instruments—to several different customers on future Shuttle flights. The SPAS itself was to be used over again.

For STS-7, both American and European experiments were fixed to the pallet. These operated while SPAS remained in the cargo bay: microgravity experiments with metal alloys, heat pipes and pneumatic conveyors; a new instrument to control a spacecraft's position by observing the Earth below, and a remote sensing scanner pointed at terrain and land/water boundaries.

During the STS-7 mission, astronaut-physician Thagard performed tests on himself and on the other crew members, measuring fluid motion and pressure increase inside the head and checking eye movement and visual perception. Researchers believe one cause of "space sickness" may be the conflict of signals sent by the inner ear's balancing system and the strange, often upside-down, visual world of being weightless in orbit.

Because of cloudy skies and rain in Florida, Challenger did not land at Kennedy Space Center, but at the backup site on the desert landing strip at Edwards Air Force Base, CA. The orbiter was dropped out of its orbit on the 97th revolution, after which it glided back to Earth and landed perfectly on target at 9:57 a.m. EDT, June 24, 6 days, 2 hours and 24 minutes after it had been launched from Florida.

This flight accomplished many firsts for the Shuttle Program: (1) repeat crewman, Capt. Crippen; (2) five-person crew; (3) detached payload operations; (4) Ku-band antenna deployed and tested; (5) U.S. woman in space (Dr. Sally Ride); (6) prolonged use of 10.2 psi cabin pressure; (7) landing without full convoy support; (8) landing without chase aircraft support; (9) use of ground cameras for landing support; (10) weather wave-off and landing on the same day at a backup site; (11) landing without Microwave Scanning Beam Landing System guidance, and (12) use of Shuttle Training Aircraft (STA) for weather flights at maximum separated distance in the U.S. Ninety-six percent (56 of 58) of the assigned flight test objectives were completed. The turnaround time was accomplished in the least time to date (only 99.5 hours) and the return to Kennedy Space Center was completed with a total of only "a 5-day loss" of program time.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. James A. Abrahamson, Associate Administrator for Space Flight; Jesse W. Moore, Deputy Associate Administrator for Space Flight; Neil B. Hutchinson, Director, Space Shuttle Operations Office; Chester M. Lee, Director, Customer Services; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems.

Goddard Space Flight Center, Greenbelt, MD

Richard Sade, Director of Networks; Gary A. Morse, Network Director; J. M. Stevens, Network Support Manager; James S. Barrowman, Project Manager, Getaway Special Program.

Johnson Space Center, Houston, TX

Glynn S. Lunney, Space Transportation Systems Program Office.

Kennedy Space Center, Cape Canaveral, FL

Thomas E. Utsman, Director, Shuttle Management and Operations; Thomas S. Walton, Director, Cargo Management and Operations; Alfred D. O'Hara, Director, Launch and Landing Operations.

Marshall Space Flight Center, Huntsville, AL

Robert E. Lindstrom, Manager, Shuttle Projects Office.

AIR FORCE P83/HILAT

Launch Vehicle — Scout Booster Rocket

Project Objective — Study communications problems.

Spacecraft Description — Spacecraft weighing 113 kilograms (259 pounds).

Project Results — Launched from Western Test Range, Vandenberg Air Force Base, CA on June 27, 1983. Orbital elements were 837 kilometers (520 miles) apogee and 771 kilometers (479) perigee. The mission was designed to aid in improving the effectiveness of communications systems through understanding the degree to which radio waves are disrupted by ionospheric plasmas and auroras. Instrumentation was developed by the Air Force Geophysics Laboratory and Johns Hopkins University's Applied Physics Laboratory.

Major Participants — Air Force Space Division, Space Test Program and Defense Nuclear Agency.

GALAXY-1

Launch Vehicle — The Delta 170 rocket, a 3920/PAM version of the launch vehicle consisting of an extended long tank first stage. The thrust of its Rocket-dyne RS-27 engine was augmented by 9 Castor IV strap-on solid motors; an improved Aerojet AJ10-118K second stage, and a Payload Assist Module (PAM), which functioned as the final stage. The entire vehicle was a uniform 2.4 meters (8 feet) in diameter (excluding the strap-on solid motors) and 35.35 meters (116 feet) in height.

Project Objective — The Galaxy-1 satellite, owned by Hughes Communications, El Segundo, CA, was to relay television programming to cable systems in the continental United States, Alaska and Hawaii.

Spacecraft Description — Galaxy-1 had a diameter of 216 centimeters (85 inches) and was 277 centimeters (109 inches) high when stowed aboard its Delta launch vehicle. In orbit, the aft solar panel deployed and the antenna reflector erected for a combined height of 683 centimeters (269 inches), or the equivalent of a two-story building. With its full load of 136 kilograms (300 pounds) of station keeping fuel, Galaxy-1 weighed 519 kilograms (1,414 pounds).

Spacecraft Payload — The satellite carried a total of 24 operating transponders. The 18 primary transponders had been sold to 6 cable programming companies. One of the remaining 6 standard transponders had been committed to another major programmer, and the rest were in various stages of negotiation.

Galaxy-1 was placed in a stationary orbit, 36,000 kilometers (22,300 statute miles) above the Equator at 134 degrees West Longitude, roughly due south of Juneau, Alaska. It operated in the 6/4 GHz C-band and had a design lifetime of at least 9 years.

Project Results — Launched from Cape Canaveral Air Force Station, FL on June 28, 1983, into geosynchronous orbit.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. J. A. Abrahamson, Associate Administrator for Space Flight; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Joseph B. Mahon, Director, Special Programs; Peter Eaton, Chief, Expendable Launch Vehicle Programs; Henry Clarks, Delta Program Manager.

Goddard Space Flight Center, Greenbelt, MD

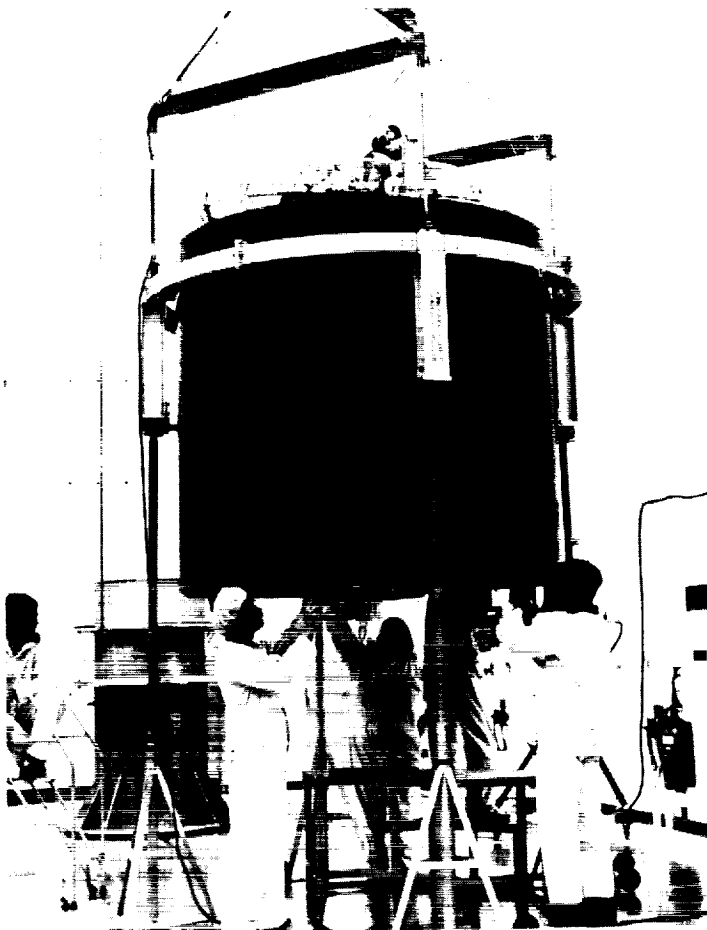
William C. Keathley, Director, Flight Projects Directorate; Robert C. Baumann, Acting Delta Project Manager; William A. Russell, Jr., Deputy Delta Project Manager; J. Donald Kraft, Manager, Delta Mission Analysis and Integration; Philip B. Frustace, Galaxy-1 Mission Integration Manager; Robert I. Seiders, Network Support Manager; Ralph Banning, Network Director.

Kennedy Space Center, Cape Canaveral, FL

Charles D. Gay, Director, Expendable Vehicles Operations; Wayne L. McCall, Chief, Delta Operations Division; Jim Weir, Head, Cargo Support Branch; Barry Olton, Spacecraft Coordinator.

Contractors

McDonnell Douglas Astronautics Company, Huntington Beach, CA, Delta Launch Vehicle; Rocketdyne Division, Rockwell International, Canoga Park, CA, First Stage Engine (RS-27); Thiokol Corp., Huntsville, AL, Castor IV Strap-on Solid Fuel Motors; Aerojet Liquid Rocket, Sacramento, CA, AJ10-118K (ITIP) Second Stage Engine; General Motors Corp., Delco Division, Santa Barbara, CA, Guidance Computer; McDonnell Douglas Astronautics Co., Huntington Beach, CA, Payload Assist Module (PAM) Third Stage.



These three photos depict launch preparations for Galaxy-1; its launch from Cape Canaveral, Florida; and the dramatic vapor trail left behind by the thundering Delta rocket.



TELSTAR 3-A

Launch Vehicle — Delta 171, a 3920/PAM version of the launch vehicle. The vehicle consisted of an extended long tank first stage (the thrust of its Rocketdyne RS-27 engine augmented by 9 Castor IV strap-on solid motors); the new improved Aerojet AJ10-118K second stage, and a Payload Assist Module (PAM), which functioned as the final stage.

The entire vehicle was 2.4 meters (8 feet) in diameter (excluding the strap-on solid motors) and 35.35 meters (116 feet) in height.

Following launch by the first 2 stages of the Delta, Telstar 3A was to be inserted into an elliptical transfer orbit by the PAM. To produce a near-geostationary orbit, an apogee kick motor mounted in the satellite itself was to be fired on the fourth orbit.

Positioning of the spacecraft was accomplished using the satellite's on-board attitude-positioning gas system. An American Telephone and Telegraph Company (AT&T) satellite control center at Hawley, Pennsylvania, directed Telstar 3A through transfer orbit to its final position in geostationary orbit. Once the satellite reached its assigned position, subsystem testing and station-keeping activities were carried out by AT&T.

Project Objectives — The Telstar 3A satellite, owned by AT&T (American Telephone and Telegraph Company) Long Lines Department, was the first in a new series of 3 domestic communications satellites providing television, telephone and information transmission services to the continental U.S., Alaska, Hawaii and Puerto Rico.

The new Telstar series was to supplement and later replace 3 of 4 COMSTAR communications satellites which AT&T had leased from The Communications Satellite Corporation (COMSAT). The COMSTARs had lifetime expectancies ending in 1984, 1985, and 1988. Following the launch of Telstar 3A, two other Telstar 3 satellites were scheduled for later launch from the Space Shuttle.

Telstar 3A was to be positioned in a geostationary orbit approximately 36,000 kilometers (22,300 statute miles) above the Equator at 96 degrees West Longitude. This orbital station was located above the Pacific Ocean at a point due south of Houston, Texas and just west of the Galapagos Islands. The satellite would operate in the 6/4 GHz C-band and had a design lifetime of at least 10 years.

Spacecraft Description — Telstar 3A had a diameter of 216 centimeters (85 inches) and was 277 centimeters (109 inches) high when stowed aboard its Delta launch vehicle. In orbit, with the aft solar panel deployed and the antenna reflector erected, the spacecraft had a height of 683 centimeters (269 inches), or the equivalent of a two-story building. The satellite weighed about 1,225 kilograms (2,700 pounds) on the ground and 663 kilograms (1,461 pounds) in orbit.

Spacecraft Payload — Telstar 3A carried a total of 24 transponders, plus six spares, to cover the 48 contiguous states, the District of Columbia, Alaska,

Hawaii and Puerto Rico. Each transponder had 5.5 watts of power and could relay one color TV signal (up to 60 million bits per second) or up to 3,900 normal two-way telephone calls. By contrast Telstar 1 was capable of providing 600 one-way voice channels or one television channel.

Project Results — Launched July 28, 1983 from Cape Canaveral Air Force Station, FL into geosynchronous orbit.

Major Participants —

NASA Headquarters, Washington DC

Lt. Gen. J. A. Abrahamson, Associate Administrator for Space Flight; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Joseph B. Mahon, Director, Special Programs; Peter Eaton, Chief, Expendable Launch Vehicle Programs; Henry Clarks, Delta Program Manager.

Goddard Space Flight Center, Greenbelt, MD

William C. Keathley, Director, Flight Projects Directorate; Robert C. Baumann, Acting Delta Project Manager; William A. Russell, Jr., Deputy Delta Project Manager; J. Donald Kraft, Manager, Delta Mission Analysis and Integration; Richard H. Schlafford, Telstar 3A Mission Integration Manager; Robert I. Seiders, Network Support Manager; Ralph Banning, Network Director.

Kennedy Space Center, Cape Canaveral, FL

Thomas S. Walton, Director, Cargo Operations; Charles D. Gay, Director, Expendable Vehicles Operations; Wayne L. McCall, Chief, Delta Operations Division; Jim Weir, Head, Cargo Support Branch; Art Sawyer, Spacecraft Coordinator.

Contractors

McDonnell Douglas Astronautics Co., Huntington Beach, CA, Delta Launch Vehicle, Rocketdyne Division, Rockwell International, Canoga Park, CA, First Stage Engine (RS-27); Thiokol Corp., Huntsville, AL, Castor IV Strap-on Solid Fuel Motors; Aerojet Liquid Rocket, Sacramento, CA, AJ10-118K (ITIP) Second Stage Engine; General Motors Corp., Delco Division, Santa Barbara, CA, Guidance Computer; McDonnell Douglas Astronautics Co, Huntington Beach, CA, Payload Assist Module (PAM) Third Stage.

STS-8/INSAT-1B

Launch Vehicle — Space Transportation System (STS) - Space Shuttle Challenger

Program Overview — See previous Space Shuttle missions.

Project Objectives and Payload — A 5-day mission commanded by Richard H. Truly, who was the pilot on the second Shuttle mission conducted in November 1981. Joining Truly were pilot Daniel C. Brandenstein and 3 mission specialists: Dale A. Gardner, Dr. Guion S. Bluford, Jr., who would become America's first black astronaut in space, and Dr. William E. Thornton.

Mission specialists Bluford and Gardner were to deploy the Indian National Satellite, INSAT-1B, from Challenger's cargo bay on the second day of the mission. A Payload Assist Module (PAM) was to boost the satellite to a geosynchronous transfer orbit.

Flight days 3 and 4 were to involve operations with the Payload Flight Test Article (PFTA) using the Canadian-built Remote Manipulator System (RMS). The 3,855.6-kilogram (8,500-pound) test article was to be used to evaluate the robot arm while handling its largest payload to date and to simulate procedures to be used on future Shuttle missions. The test article was not to be released from the arm during the flight.

Testing of the Tracking and Data Relay Satellite System (TDRSS) also was to be conducted during the mission, with guidance from the system's Network Control Center, located at GSFC.

Experiments mounted on a U-shaped pallet fixed in the cargo bay were to record the effects on various Shuttle materials of oxygen atoms which bombard the vehicle in orbit, and the first living cells were to be separated on the fourth flight on the Continuous Flow Electrophoresis System (CFES).

Of the 12 Get Away Special (GAS) canisters that were to fly inside Challenger's cargo bay, eight cans contained specially-stamped postal covers. Experiments in the other four canisters were to study making snow in space, gather contamination data, record exposure levels from Challenger's cargo bay on ultraviolet sensitive film and determine if high-energy particles encountered in space could cause errors in memory-type integrated circuits.

A Shuttle Student Involvement Project to evaluate whether or not biofeedback training, learned on Earth, could be successfully implemented in the zero gravity of space also was to be conducted.

Six rats were to be carried aboard the orbiter in a specially-designed cage, called the Animal Enclosure Module (AEM).

Project Results — Challenger was launched into a 257-kilometer (160-nautical-mile) orbit from the Kennedy Space Center in Florida at 2:32 a.m. EDT, August 30, 1983. The launch time was dictated by tracking requirements for the Indian INSAT satellite and also served to demonstrate the Shuttle's ability to launch at night, when weather conditions in Florida are often more favorable than during

the day. The vehicle's ascent into orbit was normal, as was the performance of the first of a new group of lighter, more powerful solid rocket boosters.

The Challenger orbiter and its crew performed the first tests of Shuttle-to-ground communications using Goddard's new Tracking and Data Relay Satellite (TDRS); delivered India's INSAT 1B satellite successfully into orbit; exercised the Remote Manipulator System (RMS) arm with its heaviest load to date; further developed the experimental Continuous Flow Electrophoresis System; flight-tested an incubator and animal enclosure for use in biological experiments on future flights; carried 260,000 special postal covers into orbit; performed tests on the space environment's effect on astronauts and on man-made materials, and successfully demonstrated both a night launch and a night landing.

Although a computer software problem at the White Sands ground station caused a temporary loss of TDRS relay on the mission's second day, the problem was solved by the next morning, and satellite checkouts resumed. The tests verified that the Challenger and TDRS automatically could lock onto and track each other's signal in both frequencies. Technicians checked how radio contact was affected by different orbiter attitudes and maneuvers, including rolling and pitching the vehicle end-over-end. For one test, Challenger's Ku-band antenna was used to acquire the TDRS signal "manually" after it deliberately had been pointed away from the satellite. An encryption technique for sending coded radio messages also was demonstrated to support future missions with classified data.

By mission's end, all of the TDRS communication modes successfully had been proven. There were still problems to be smoothed out with ground software, but the relay satellite showed its readiness for operational support of the STS-9 Spacelab mission.

Because this was the Shuttle's first night landing, Edwards Air Force Base in California, where a large flat lakebed surrounds the landing strip, was used. Challenger performed a de-orbit engine burn on its 97th revolution around the Earth and entered the atmosphere. Astronauts Truly and Brandenstein were aided in their final approach by high intensity xenon arc-lights that illuminated the runway. The orbiter had no landing lights of its own, due to the complications of designing outside lights that could withstand the heat of a re-entry. However, with the experience of dozens of practice night landings in Shuttle training aircraft to guide them, Truly and Brandenstein piloted Challenger down out of the darkness and landed on time and on target at Edwards, 300 feet from their runway aim point. Challenger's wheels stopped rolling on the landing strip at 3:41 a.m. EDT, September 5, 1983.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. James A. Abrahamson, Associate Administrator for Space Flight, Jesse W. Moore, Deputy Associate Administrator for Space Flight; Neil B. Hutchinson,

Director, Space Shuttle Operations Office; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Robert O. Aller, Program Director, Tracking Data Relay Satellite Systems (TDRSS).

Dryden Flight Research Facility, Edwards, CA

Gary Layton, Shuttle Project Manager

Goddard Space Flight Center, Greenbelt, MD

Richard Sade, Director of Networks; Gary A. Morse, Network Operations Director; J. M. Stevens, Network Support Manager.

Johnson Space Center, Houston, TX

Clifford E. Charlesworth, Director of Space Operations; Henry E. Clements, Associate Director; Glynn S. Lunney, Manager, Space Transportation Systems Program Office.

Kennedy Space Center, Cape Canaveral, FL

Thomas E. Utsman, Director, Shuttle Management and Operations; Thomas S. Walton, Director, Cargo Management and Operations; Alfred D. O'Hara, Director, Launch and Landing Operations; Robert B. Sieck, STS-8 Flow Director.

Marshall Space Flight Center, Huntsville, AL

Robert E. Lindstrom, Manager, Shuttle Projects Office; James E. Kingsbury, Director, Science and Engineering.

RADIO CORPORATION OF AMERICA (RCA)-G/ RCA-SATCOM-11R

Launch Vehicle — Delta 3924, consisted of an extended long tank first stage with Rocketdyne RS-27 engine and 9 Castor IV strap-on solid motors for the first stage; an improved Aerojet AJ10-118K second stage, and a Thiokol TE-364-4 third stage engine. The entire vehicle was 2.4 meters (8 feet) in diameter (excluding the strap-on motors) and 35.357 meters (116 feet) in height.

McDonnell Douglas Astronautics Corporation, Huntington Beach, CA, was the prime contractor for production and launch of the Delta launch vehicle. The apogee kick motor, mounted inside the spacecraft itself, was a Thiokol Star 30 motor.

Project Objectives — RCA-G, also designated RCA-SATCOM-11R, was to replace RCA-SATCOM-11, launched March 1976 as RCA's second domestic communication satellite. The 24-channel satellite was to provide voice, data and video services to the continental U.S.

RCA-G was to join four other operating RCA satellites in orbit: SATCOMS 1R, 111R, IV and V to maintain a 5 satellite RCA network providing coverage of all 50 states, the District of Columbia and Puerto Rico for television, voice channels and high speed data transmission.

RCA Earth stations were located near New York City, San Francisco and Los Angeles, and at Anchorage, Juneau, Nome, Rothel, Valdez and Prudhoe Bay in Alaska.

More than 4,000 Earth stations had direct access to these spacecraft.

Spacecraft life, with continuous full power, was designed to be 10 years.

Spacecraft Description — With solar panels deployed, the satellite spanned 15.78 meters (51.8 feet). The spacecraft main body measured 1.42 by 1.62 by 1.75 meters (4.6 by 5.3 by 5.7 feet).

The RCA-SATCOM-G's total transfer weight, including the Star 30 apogee motor, was 1,116.9 kilograms (2,460 pounds). On-orbit weight was 589.5 kilograms (1,299 pounds).

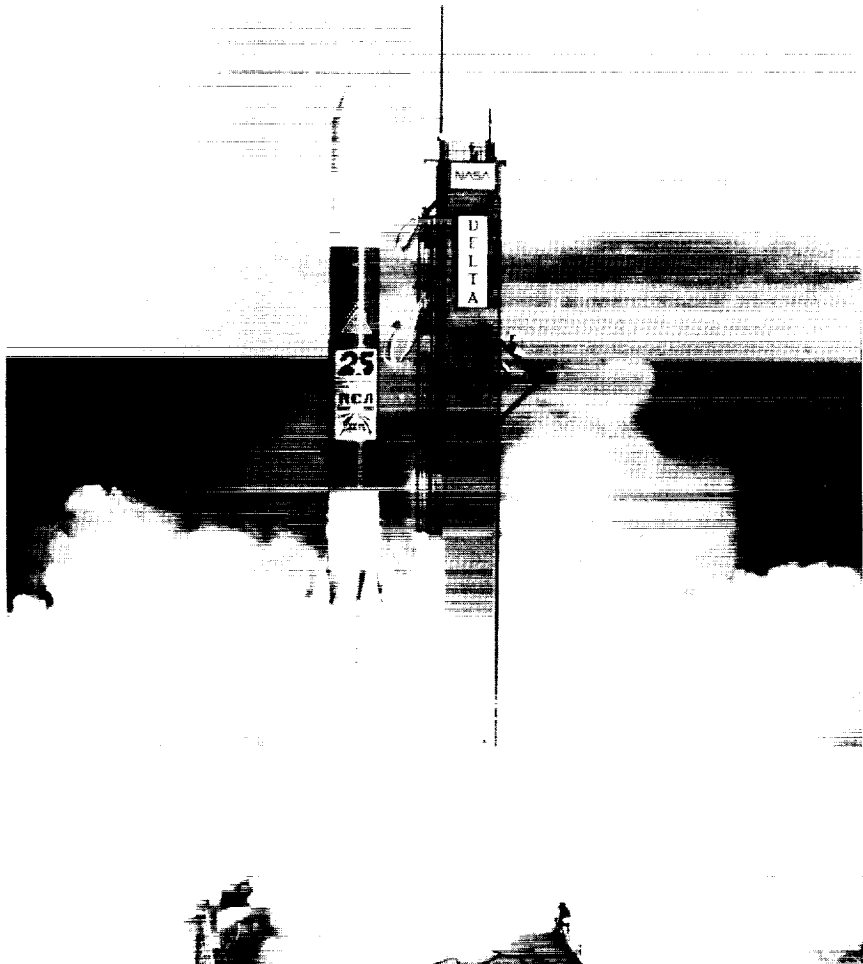
The three-axis stabilized spacecraft was equipped with the power, attitude control, thermal control, propulsion, structure and command, ranging and telemetry necessary to support mission operations from booster separation through 10 years of geosynchronous orbit.

Spacecraft Payload — A 24-channel communications satellite providing voice, data and video services to the continental U.S.

Project Results — Launched into geosynchronous orbit from Cape Canaveral Air Force Station, FL on September 8, 1983.

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Delta 171 launches RCA-G, a video commercial communications satellite. It was launched from Complex 17A, Cape Canaveral Air Force Station, Florida.



Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. J. A. Abrahamson, Associate Administrator for Space Flight; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Joseph B. Mahon, Director, Special Programs; Peter Eaton, Chief, Expendable Launch Vehicle Program; Henry Clarks, Delta Program Manager.

Goddard Space Flight Center, Greenbelt, MD

William C. Keathley, Director, Flight Projects Directorate; Robert C. Baumann, Acting Delta Project Manager; William A. Russell, Jr., Deputy Delta Project Manager; J. Donald Kraft, Manager, Delta Mission Analysis and Integration; Richard H. Schlafford, RCA-G Mission Integration Manager; Robert Seiders, RCA-G Network Support Manager; Ralph Banning, RCA-G Mission Support.

Kennedy Space Center, Cape Canaveral, FL

Thomas S. Walton, Director, Cargo Operations; Charles D. Gay, Director, Expendable Vehicles Operations; Wayne L. McCall, Chief, Delta Operations Division; Jim Weir, Head, Cargo Support Branch; J. B. Roberts, Spacecraft Coordinator.

RCA American Communications Inc., Princeton, NJ

Dr. James J. Tietjen, President; John Christopher, Vice President of Technical Operations; Joseph Schwarze, Director, Space Systems; William Palme, Manager, Advanced Space Programs; Joseph Elko, Manager, Spacecraft Engineering.

Contractors

RCA Government Systems, RCA Astro Electronics Div., Princeton, NJ, Spacecraft Management Development/Production; McDonnell Douglas Astronautics Co., Huntington Beach, CA, Delta Launch Vehicle; Rocketdyne Division, Rockwell International, Canoga Park, CA, First Stage Engine (RS-27); Thiokol Corp., Huntsville, AL, Castor IV Strap-on Solid Fuel Motors; Aerojet Liquid Rocket Co., Sacramento, CA, AJ10-118K; Thiokol Corp., Elkton, MD, TE364-4 Third Stage Engine.

Major Subcontractors

SPAR Aerospace Division, Ste-Anne-de-Bellevue, Quebec, Canada, Antenna Input and Output; Charles Stark Draper Labs, Cambridge, MA, Momentum Wheel Assembly; Lockheed Space Systems Division, Sunnyvale, CA, Earth Sensor Assembly and Horizon Sensor Assembly; Thiokol Corp., Elkton, MD, Apogee Kick Motor (Star 30) in Spacecraft; Hughes Aircraft Co., Electro Dynamics Division, Torrance, CA, Traveling Wave Tube Amplifiers; Rocket Research, Redmond, WA, Reaction Engine Assembly; Cubic Corp., Defense Systems Division, San Diego, CA, Beacon Transmitter and Command Receiver; Parsons of California, Stockton, CA, Structure and Solar Panels; Adcole Corp., Waltham, MA, Sun Sensor Assembly; Northrop Corp., Norwood, MA, Rate Measuring Assembly.

GALAXY-2

Launch Vehicle — The Delta rocket for this mission was the 173rd to be launched in the Delta series. The 3920/PAM version of the launch vehicle consisted of an extended long tank first stage, the thrust of its Rocketdyne RS-27 engine augmented by 9 Castor IV strap-on solid motors; the new improved Aerojet AJ10-118K second stage, and a Payload Assist Module (PAM), which functioned as the final stage.

The entire vehicle was 2.4 meters (8 feet) in diameter (excluding the strap-on solid motors) and 35.35 meters (116 feet) in height. McDonnell Douglas Astronatics Corp., Huntington Beach, California, was the prime contractor for production and launch of the Delta vehicle.

Following launch by the first 2 stages of the Delta 3920, Galaxy-2 was to be inserted into an elliptical transfer orbit by the PAM, rather than a conventional third stage. The PAM, built by McDonnell Douglas, was attached to the satellite.

To produce a near-stationary orbit, an apogee kick motor (Thiokol Corporation's Star 30 solid propellant rocket) mounted in the satellite itself was to be fired. Positioning of the spacecraft was to follow, using the satellite's on-board attitude positioning gas system.

Project Objective — Relay business communications throughout the United States. One half the satellite's capacities, or 12 transponders, had been purchased by MCI Communications Corp. to be used as an industrial educational network. Programs to be carried were to be televised to employees and customers for internal communications, product familiarization and other uses. IBM was to use a portion of one other transponder, and the remainder of the spacecraft's capacity was for sale.

Spacecraft Description — Galaxy-2 had a diameter of 216 centimeters (85 inches) and was 277 centimeters (109 inches) high when stowed aboard its Delta launch vehicle. In orbit, the aft solar panel deployed and the antenna reflector erected for a combined height of 683 centimeters (269 inches), or the equivalent of a two story building. With its full load of 136 kilograms (300 pounds) of station-keeping fuel, Galaxy-2 weighed 519 kilograms (1,144 pounds). Galaxy-2 was built for Hughes Communications, Inc. by the Hughes Aircraft Company's Space and Communications Group, El Segundo, CA. It was the second in a series of 3 Galaxy satellites.

Spacecraft Payload — The satellite carried a total of 24 transponders. Galaxy-2 was to be positioned in a stationary orbit 36,000 kilometers (22,300 statute miles) above the equator at 74 degrees West Longitude, roughly due south of New York City. It operated in the 6.4 GHz C-band and had a design lifetime of at least 9 years. The Hughes Operations Control Center directed Galaxy-2 through transfer orbit to its final position in stationary orbit. Once the satellite reached its assigned position, subsystem testing and station-keeping activities would be carried out by Hughes.

Project Results — Launched from Cape Canaveral Air Force Station, FL on September 22, 1983 into geosynchronous orbit.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. J. A. Abrahamson, Associate Administrator for Space Flight; Robert E. Smylie, Associate Administrator for Space Tracking and Data Systems; Joseph B. Mahon, Director, Special Programs; Peter Eaton, Chief, Expendable Launch Vehicle Programs; Henry Clarks, Delta Program Manager.

Goddard Space Flight Center, Greenbelt, MD

William C. Keathley, Director, Flight Projects Directorate; Robert C. Baumann, Acting Delta Project Manager; William A. Russell, Jr., Deputy Delta Project Manager; J. Donald Kraft, Manager, Delta Mission Analysis and Integration; Philip B. Frustace, Galaxy-2 Mission Integration Manager; Robert I. Seiders, Network Support Manager; Ralph Banning, Network Director.

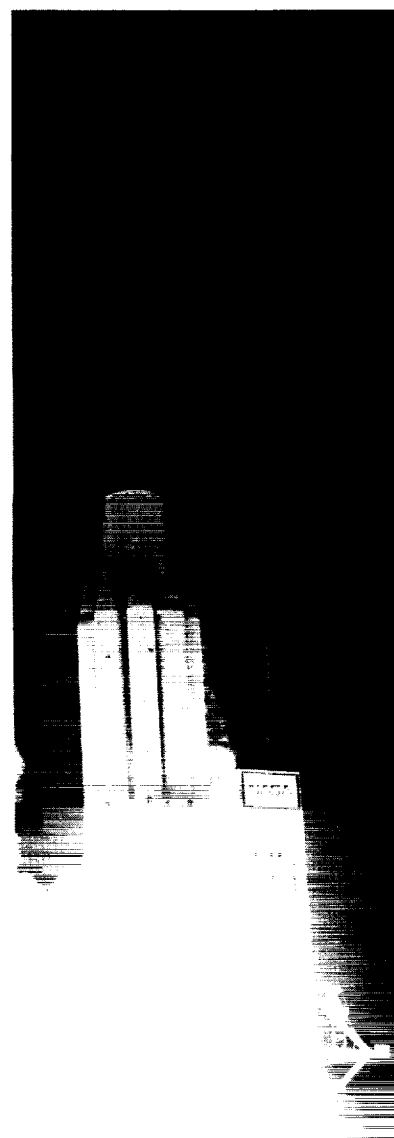
Kennedy Space Center, Cape Canaveral, FL

Charles D. Gay, Director, Expendable Vehicles Operations; Wayne L. McCall, Chief, Delta Operations Division; Jim Weir, Head, Cargo Support Branch; Barry Olton, Spacecraft Coordinator.

Contractors

McDonnell Douglas Astronautics Co., Huntington Beach, CA, Delta Launch Vehicle; Rocketdyne Division, Rockwell International, Canoga Park, CA, First Stage Engine (RS-27); Thiokol Corp., Huntsville, AL, Castor IV Strap-on Solid Fuel Motors; Aerojet Liquid Rocket, Sacramento, CA, AJ10-118K (ITIP) Second Stage Engine; General Motors Corp., Delco Division, Santa Barbara, CA, Guidance Computer; McDonnell Douglas Astronautics Co., Huntington Beach, CA, Payload Assist Module (PAM) Third Stage.

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Hughes Communications built the Galaxy-2 communications satellite being launched here. It was to be stationed at 74 degrees West Longitude above the equator.

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STS-9/ SPACELAB 1

Launch Vehicle — Space Transportation System (STS) - Space Shuttle Columbia.

Program Overview — See previous STS missions.

Project Objectives — The ninth flight of the Space Shuttle, STS-9/Spacelab 1, was a 9-day, international space research expedition. It was to mark the maiden flight of the newest element of the Space Transportation System, the European Space Agency (ESA)-developed laboratory called Spacelab.

This flight was to be the first time ever that career scientists from outside NASA's astronaut corps were to fly aboard a United States spacecraft to conduct research.

For STS-9, Spacelab was to occupy orbiter Columbia's cargo bay, temporarily transforming the Shuttle orbiter into a space-based orbital research center—a short-stay scientific space station.

Spacelab was designed, developed, funded and built by the European Space Agency as Europe's contribution to the United States Space Transportation System. It represented a European investment of approximately \$1 billion.

The STS-9 orbiter and Spacelab's basic systems were to be controlled from the Mission Control Center at NASA's Johnson Space Center, Houston, TX.

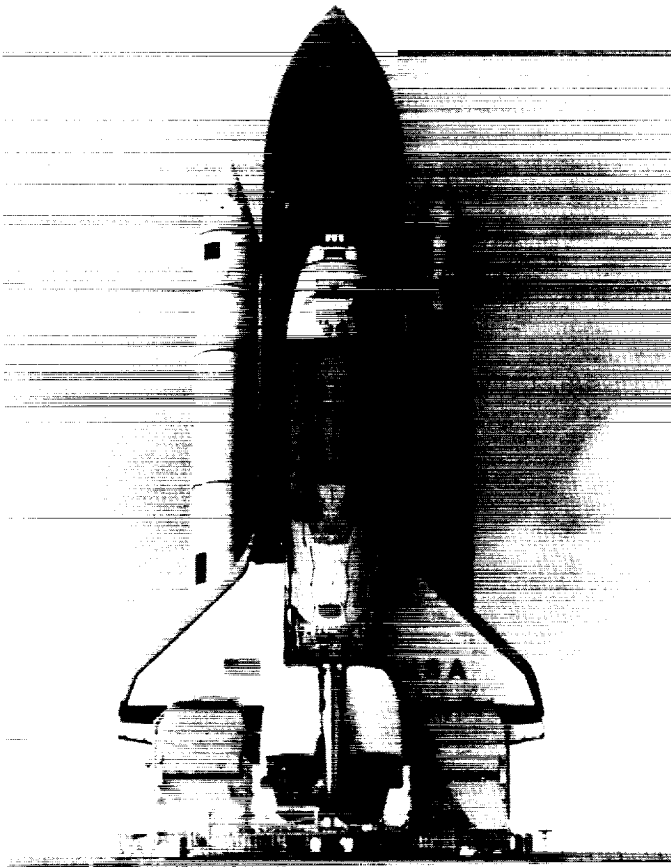
All Spacelab 1 science operations on-orbit were to be managed and controlled from the Payload Operations Control Center situated in the same building as Mission Control at the Johnson Space Center. Members of the Marshall Center-Spacelab Payload Integration and Coordination in Europe (SPICE) mission management team, along with the teams of scientists with experiments aboard Spacelab, were to monitor, direct and control experiment operations throughout the mission.

During the mission, NASA's new Tracking and Data Relay Satellite System (TDRSS) was to handle most of the communications and data transmissions between Columbia/Spacelab 1 and Mission and Payload Control. NASA's worldwide Ground Space Tracking and Data Acquisition Network (GSTDN) would continue to be used; however, the addition of TDRSS was to vastly increase the amount of data and communications that could be exchanged between the spacecraft and the ground during the mission. STS-9/Spacelab 1 would also mark the first use of the Spacelab Data Processing Facility at Goddard Space Flight Center, where more than 6 trillion bits of scientific data were received and processed.

Project Payload — The mission was to test the laboratory and to conduct more than 70 separate investigations in five broad areas of scientific research: life sciences, atmospheric physics and Earth observations, astronomy and solar physics, space plasma physics and materials science and technology.

Spacelab 1 was a joint mission of NASA and ESA with each organization sponsoring half (by resources) of the scientific payload. Experiments for the mission were provided and supported by scientists in 11 European nations, the

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What appears to be an "X-Ray" photograph shows the European Space Agency Spacelab installed in Columbia's cargo bay. The photo is a deliberate double exposure made during check out. Spacelab was launched on November 28, 1983.



These 6 men represented the first crew members to man the Columbia. The four NASA astronauts were joined by a European and MIT scientist payload specialist and the Spacelab module and experiment array for STS-9. On the front row are Astronauts Owen K. Garriott, mission specialist; Brewster H. Shaw, Jr., pilot; John W. Young, commander; and Robert A. R. Parker, mission specialist. Byron K. Lichtenberg of the Massachusetts Institute of Technology, left, and Ulf Merbold of the Republic of West Germany and the European Space Agency stand in front of an orbital scene featuring the Columbia.

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United States, Canada and Japan. Marshall Space Flight Center, Huntsville, AL, was responsible for the NASA-sponsored portion of the payload and for overall management of the mission. ESA's Spacelab Payload Integration and Coordination in Europe (SPICE) team was responsible for the European portion of the payload.

The 6-man crew of STS-9/Spacelab 1 was the largest crew yet to fly aboard a single spacecraft, the first international Shuttle crew and the first crew to include a new category of spaceborne research scientists called payload specialists.

Mission commander was John W. Young, veteran of 5 previous space flights and commander of the first Space Shuttle mission. Pilot was Brewster H. Shaw, Jr., who was making his first space flight. Mission specialist astronauts were Dr. Owen K. Garriott, a veteran of NASA's Skylab 3 mission, and Dr. Robert A. R. Parker, who was making his first space flight. The payload specialists were Dr. Byron Lichtenberg, a member of the research staff at the Massachusetts Institute of Technology and an Air National Guard pilot from Cambridge, Massachusetts, and Dr. Ulf Merbold, representing ESA, from the Federal Republic of Germany. Merbold was the first non-American to fly on a U.S. spacecraft.

Project Results — With Spacelab in its cargo bay and a 6-man crew onboard, Columbia was launched from Kennedy Space Center, FL at 11:00 a.m. on November 28, 1983.

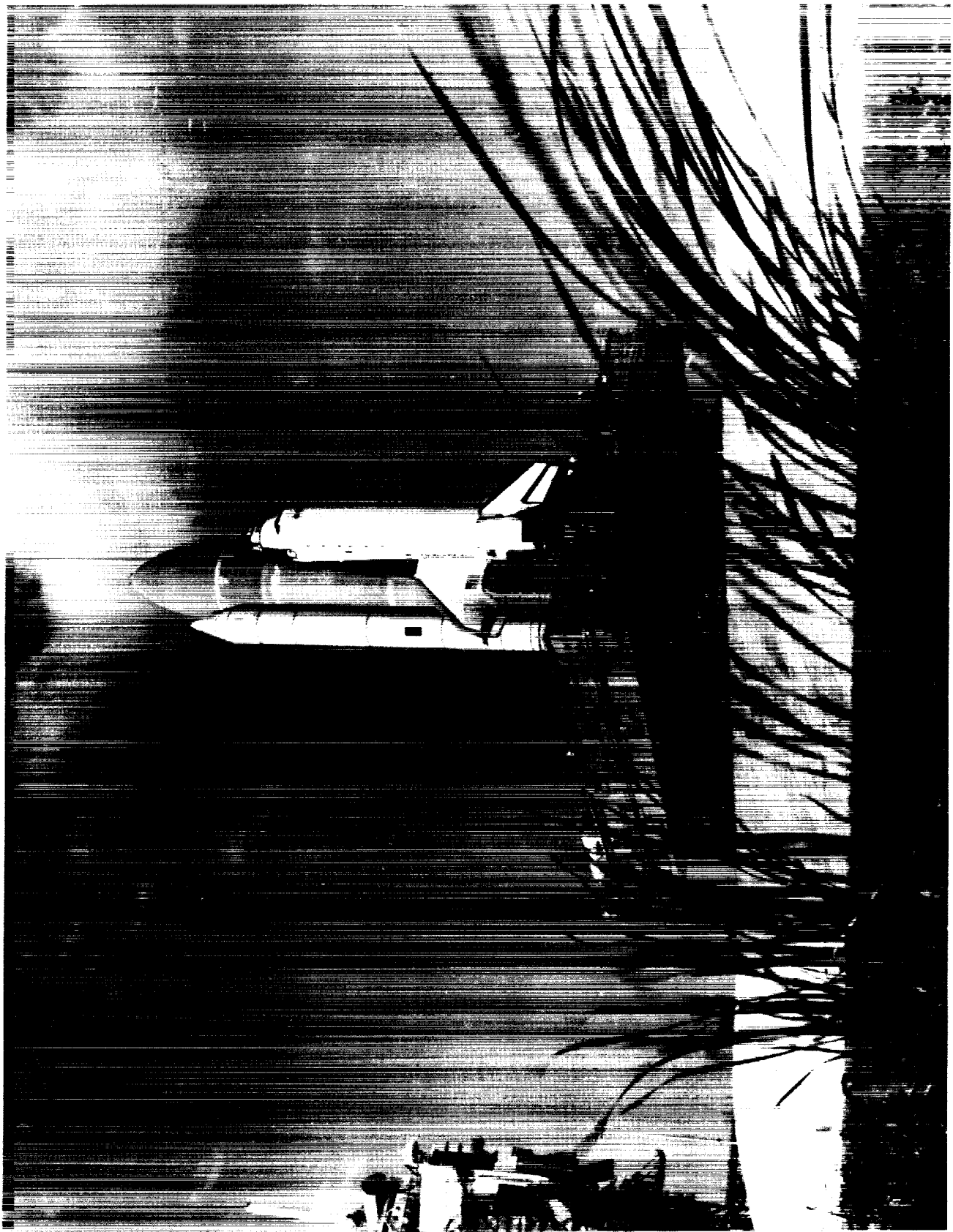
Following the launch and insertion into a 250 kilometer (155 mile)-high orbit, the crew opened Columbia's payload bay doors and powered up Spacelab's electrical systems. Just under 4 hours into the mission, Garriott, Merbold and Lichtenberg floated from the orbiter mid-deck through a connecting tunnel to enter the Space Shuttle's newest "room" and began initial checkouts.

STS-9 was Spacelab's verification flight, not only for the hardware in Columbia's cargo bay, but also for the entire network of communications between the astronaut-scientists in orbit and scientists on the ground in the Payload Operations Control Center (POCC) at Johnson Space Center. From inside the POCC, investigators who designed experiments for this Spacelab had frequent discussions with the crew members in orbit — going over procedures, troubleshooting, making additions to the experiments and generally involving themselves in the work taking place in space. This interaction made Spacelab unique.

Among the firsts for STS-9 were the continuous crew operations in orbit, so that science experiments could operate 24 hours a day. The "Red Team" of Young, Parker and Merbold rotated on a 12-hour work-then-sleep schedule with the "Blue Team" of Shaw, Garriott and Lichtenberg. During these 12-hour duty cycles, the commander or pilot would monitor Columbia's systems from the orbiter flight deck and change the vehicle's attitude to point instruments toward selected astronomical or Earth targets.

Shortly after entering Spacelab at the beginning of the flight, the Blue Team began the first of the mission's 9 full days of scientific investigations. Spacelab 1 was designed to host a wide variety of experiment disciplines to demonstrate

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Space Shuttle Columbia creeps up the ramp at Launch Pad 39A at the completion of the move from the Vehicle Assembly Building.

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the lab's versatility. Some experiments returned data immediately to scientists in Houston, while other instruments photographed or recorded data to be studied in detail after Columbia's landing.

On the mission's sixth day, project managers decided to extend the flight by 1 day to allow more time for experiments. The crew used this extra day to conduct additional experiments, including several fluid physics demonstrations improvised on-the-spot by ground scientists and the Spacelab crew.

On its ninth day in orbit, the crew completed and stowed the last of the science experiments, deactivated the Spacelab and prepared to return to Earth. Just under 4 hours before the scheduled deorbit engine burn, however, a jolt from Columbia's attitude control rockets caused the failure of first one, then another of the orbiter's 5 general purpose computers. Six hours later, 1 of the 3 Inertial Measurement Units (IMU) used for vehicle navigation also failed. Although one of the computers was restored to service (Columbia needed only 1 of the 5 computers to land), it was decided to delay the landing while engineers on the ground evaluated the problem.

At 3:47 p.m. (PST) on December 8, 1983, 7½ hours after the scheduled landing time, Columbia landed safely at Edwards Air Force Base in California. One of the computers failed on landing and several small fires caused by fuel leaks were discovered around two of the spacecraft's hydraulic power units after touchdown. Although these problems warranted further investigation by project managers, they did not endanger either the Spacelab or the crew, and the international Spacelab 1 mission was pronounced a success after 10 highly-productive days of science in orbit.

Of the 72 experiments flown on Spacelab, none was more impressive than the metric camera, which photographed more than seven million square miles of the Earth from space. Unique high-quality images with a ground resolution of 20 meters (60.5 feet) were obtained for many of the world's regions for the first time.

Spacelab proved that the Earth could be mapped from space and that the mapping of the 60 percent of the Earth that was still uncharted could be done faster and more cheaply from space than from the air.

The telescope, which looked at ultraviolet rays from stars that are invisible to the naked eye, proved almost as resourceful as the metric camera. When the telescope was focused on the two Large Magellanic Clouds, it peered through the dust between the clouds and found many stars there.

Just as beneficial were the studies in materials science performed aboard the 4.5 meters (14.5-foot-long) laboratory in the 10 days that it was in orbit. Silicon crystals, which are important in electronic components, were grown in Spacelab 3 to 4 times larger and purer than any grown on Earth.

Also, 2 human proteins were grown in Spacelab. One was grown to 27 times the size it had been grown in pharmaceutical laboratories on Earth and the other to 1,000 times that size.

Major Participants —

NASA Headquarters, Washington, DC

Lt. Gen. James A. Abrahamson, Associate Administrator for Space Flight; Jesse W. Moore, Deputy Associate Administrator for Space Flight; L. Michael Weeks, Deputy Associate Administrator/Technical; Neil B. Hutchinson, Director, Space Shuttle Operations Office; James C. Harrington, Director, Spacelab Division; Robert L. Lohman, Chief, Development, Spacelab Division; Alfred L. Ryan, Chief, Operations, Spacelab Division; Dr. Burton I. Edelson, Associate Administrator for Space Science and Applications; Samuel W. Keller, Deputy Associate Administrator for Space Science and Applications; Dr. Jeffrey D. Rosendahl, Assistant Associate Administrator for Space Science and Applications (Science); Michael J. Sander, Director, Spacelab Flight Division; Richard Halperin, Acting Deputy Director, Spacelab Flight Division; Mary Jo Smith, Spacelab 1 Program Manager; Dr. Arnauld Nicogossian, M.D., Director, Life Sciences Division; Robert O. Aller, Associate Administrator for Space Tracking and Data Systems.

Dryden Flight Research Facility, Edwards, CA

John Manke, Facility Manager; Gary Layton, Shuttle Project Manager.

Goddard Space Flight Center, Greenbelt, MD

Richard Sade, Director of Networks; Gary A. Morse, Network Operations Director; J. M. Stevens, Network Support Manager; William P. Barnes, Head, High Rate Data Handling Section; Ron Browning, Project Manager, TDRSS.

Jet Propulsion Laboratory, Pasadena, CA

Dr. Lew Allen, Director.

Johnson Space Center, Houston, TX

Glynn S. Lunney, Manager, Space Transportation System Program Office; Arnold D. Aldrich, Manager, Space Shuttle Project Office; Clifford E. Charlesworth, Director, Space Operations; Charles Lewis, Lead Flight Director, STS-9; Aaron Cohen, Director, Research and Engineering; William Huffstedtler, JSC Spacelab Mission Division Manager; John O'Loughlin, JSC Spacelab Mission Engineer.

Kennedy Space Center, Cape Canaveral, FL

Thomas E. Utsman, Director, Shuttle Management and Operations; Thomas S. Walton, Director, Cargo Management and Operations; Alfred D. O'Hara, Director, Launch and Landing Operations; Wiley E. Williams, Director, STS Cargo Operations; Eldon Raley, Cargo Manager; James F. Harrington, III, STS-9 Flow Director.

Marshall Space Flight Center, Huntsville, AL

James E. Kingsbury, Director, Science and Engineering; Robert E. Lindstrom, Manager, Shuttle Projects Office; John W. Thomas, Manager, Spacelab Program Office; James A. Downey, III, Manager, Spacelab Payload Project Office; Harry G. Craft, Jr., Spacelab 1 Mission Manager; Dr. Charles Chappell, Spacelab 1 Mission Scientist.

European Space Agency (ESA)

Eric Quistgaard, ESA Director General; Michel Bignier, Director, Space Transportation; Jan. A. Bijvoet, Spacelab Development Coordination; Dai J. Shapland, Spacelab Utilization.

Spacelab Development

Dr. B. Pfeiffer, Spacelab Project Manager, succeeded by G. Altmann, as of July 1, 1983; F. Longhurst, Spacelab Sustaining Engineering; A. Thirkettle, Manager, European Resident Team at KSC; L. Tegman, Product Assurance and Safety; M. Legg, Project Control; J. Paque, Configuration Data Management; P. Wolf, IPS Development; D. von Eckardstein, Spacelab Follow-on Production; W. Nellessen, Systems.

Spacelab Payload Integration and Coordination in Europe (SPICE)

D. Mullinger, Head, SPICE; A. Dodeck, Engineering; C. Reinhold, Experiment and Crew Activities; C. Nicollier, U. Merbold, and W. Ockels, ESA Science Astronauts.

Contractors:

European Space Agency - Prime Contractor for Spacelab Development

VFW-Fokker Erno (Later MBB-ERNO), Federal Republic of Germany, Project Management, System Engineering, Product Assurance, Integration, Test Operations, Crew Habitability, Igloo Thermal Control, Miscellaneous Spacelab Components and Services.

Co-Contractors

AEG Telefunken Industries, Federal Republic of Germany, Electrical Power Distribution Subsystem; Aeritalia, Italy, Module Structure Environmental and Thermal Control Subsystem, Igloo; Bell Telephone Manufacturing Co., Belgium, Electrical Systems Ground Support Equipment; Dornier Systems, Federal Republic of Germany, Instrument Pointing System, Pointing Subsystem Environmental Control/Life Support Subsystem; Fokker, The Netherlands, Scientific Airlock; British Aerospace, United Kingdom, Pallet Structure; Kampsax, Denmark, Computer Software; MATRA, France, Command and Data Management Subsystem; SABCA, Sweden, Igloo Structure, Utility Bridge, Common Payload Support Equipment; Sener, Spain, Mechanical Ground Support Equipment.

NASA - Prime Contractor for Spacelab Support

McDonnell Douglas Technical Services Co., Huntsville, AL, and Kennedy Space Center, FL, Integration of Spacelab into Shuttle.

Spacelab 1, NASA Investigation and Principal Investigators:

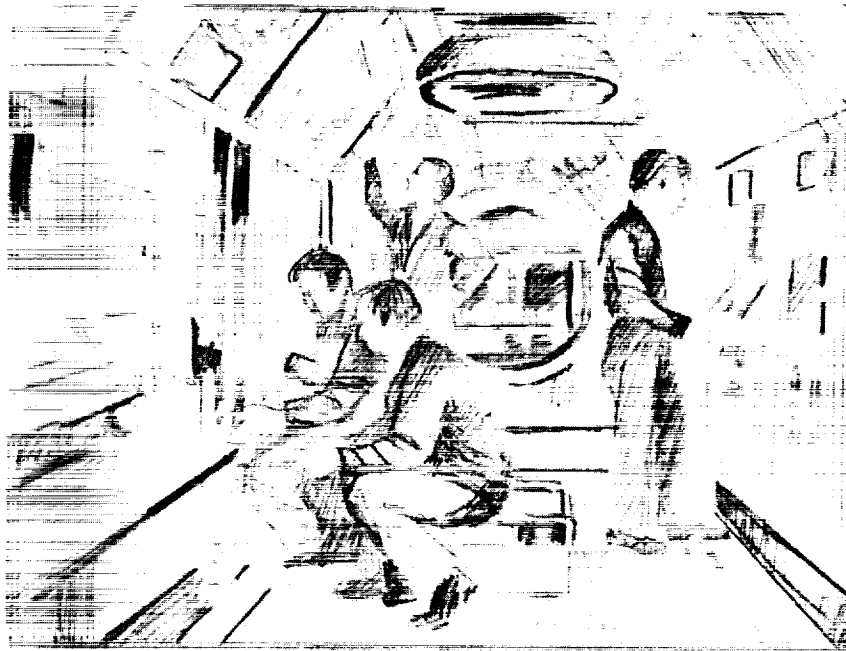
Discipline	Title	PI Name/Organization
Atmospheric Physics	Imaging Spectrometric Observatory	M. Torr (University of Michigan)
Plasma Physics	Space Experiments with Particle Accelerators	T. Obayashi (University of Tokyo)
Solar Physics	Active Cavity Radiometer Solar Irradiance Monitor	R. Willson (Jet Propulsion Laboratory)
Astronomy	Far UV Observations Using Faust Instrument	S. Bowyer (University of California, Berkeley)
Life Sciences	Radiation Environment Mapping	E. Benton (University of San Francisco)
	Characterization of Persisting Circadian Rhythms	F. Sulzman (Harvard University)
	Life Science Minilab	
	Nutation of <i>Helianthus annuus</i>	A. Brown (University of Pennsylvania)
	Vestibular Experiments	L. Young (Massachusetts Institute of Technology)
	Space Flight Influence on Erythrokinetics in Man	C. Leach (Johnson Space Center)
	Vestibulo-Spinal Reflex Mechanisms	M. Reschke (Johnson Space Center)
	Effects on Prolonged Weightlessness	E. Voss (University of Illinois)
Technology	Tribology Experiments in Zero-Gravity	C. Pan (Shaker Research)
		R. Gause and A. Whitaker (Marshall Space Flight Center)

Spacelab 1, ESA Investigations and Principal Investigators:

Discipline	Title	PI Name/Country
Atmospheric Physics	Grille Spectrometer	M. Ackerman/Belgium
	Waves in the OH Emissive Layer	M. Herse/France
	Solar Spectrum from 1900 A-4 Micron	G. Thuillier/France
	Lyman-Alpha H and D	L. Bertaux/France
Plasma Physics	Low-Energy Electron Flux DC-Magnetic Field Vector Measurement Phenomena Induced by Charged Particle Beams	C. Beghin/France
Solar Physics	Solar Constant Measurement	D. Crommelynck/Belgium
Astronomy	Very Wide Field Camera (VWFC)	G. Courtes/France
	Spectroscopy in X-Ray Astronomy	D. Andresen/ESA-ESTC
	Isotopic Stack Experiment	R. Beaujean/W. Germany
Material Sciences	Material Science Double Rack (MSDR)	U. Huth/W. Germany
	Organic Crystal Growth	Denmark/France
	Crystal Growth of Mercury Iodide	C. Belouet/France
Life Sciences	Mass Discrimination During Weightlessness	H. Ross/UK
	Measurement of Intrathoracic Venous Pressure, Collection of Blood Samples	K. Kirsch/W. Germany
	Advanced Biostack Experiment	H. Bucker/W. Germany
	3-Dimensional Ballistocardiography	A. Scano/Italy

Spacelab 1, ESA Investigations and Principal Investigators: (continued)

Discipline	Title	PI Name/Country
Life Sciences (continued)	Effect of Radiation	G. Horneck/W. Germany
	Electrophysiological Tape Recorder	H. L. Green/UK
	Lymphocyte Proliferation in Weightlessness	A. Cogoli/Switzerland
	Effects of Rectilinear Acceleration Optokinetic, and Caloric Stimuli in Space	R. V. Baumgarten/W. Germany
Earth Obser- vations	Metric Camera	W. Germany
	Microwave Remote Sensing Experiment	W. Germany



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